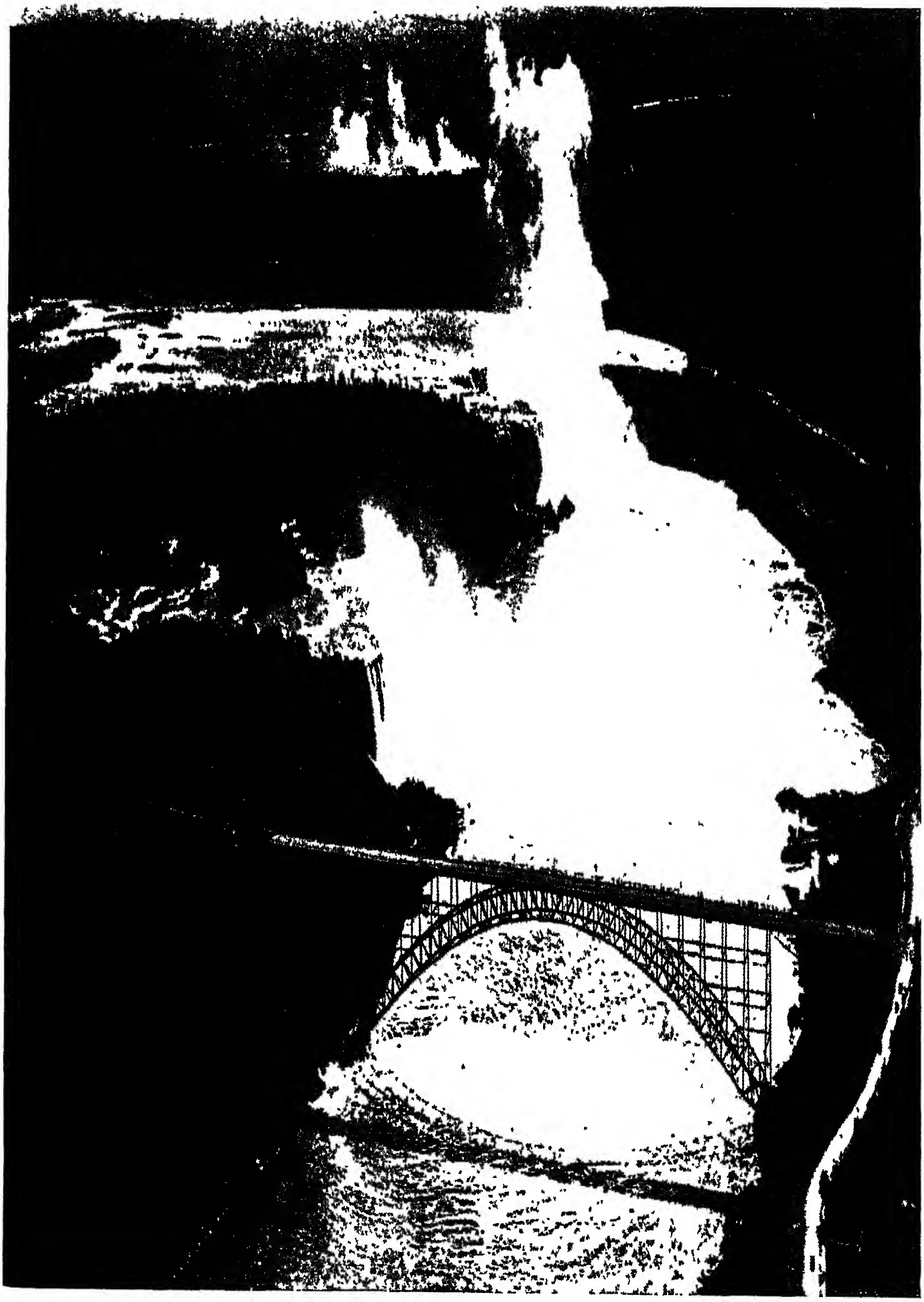
NIAGARA POWER



AEROPLANE VIEW OF NIAGARA RIVER ABOVE AND BELOW THE AMERICAN AND CANADIAN FALLS

The International Steel Arch Bridge Showing at Its Left Foundation the Portal of the Discharge Tunnel of The Niagara Falls Power Company

NIAGARA POWER

HISTORY OF

THE NIAGARA FALLS POWER COMPANY

1886–1918

EVOLUTION OF ITS

CENTRAL POWER STATION *and* ALTERNATING CURRENT SYSTEM

[IN TWO VOLUMES]

VOLUME I

HISTORY AND POWER PROJECTS

By

EDWARD DEAN ADAMS

M.A., M.S., LL.D.

JOHN FRITZ MEDALIST

MCMXXVI

PRIVATELY PRINTED FOR

THE NIAGARA FALLS POWER COMPANY

MCMXVIII

NIAGARA FALLS, N. Y.

ON THE FIFTIETH ANNIVERSARY OF ITS FOUNDATION

1927

TRIBUTE OF APPRECIATION

For the co-operation of members of the Schoellkopf organization in the preparation of this record, assurances of appreciation are extended.

Acknowledgments are also made for the assistance received from associates in this adventure, who contributed in so many ways to make the record accurate as well as complete, thirty years after achievements had crowned our undertaking.

THE AUTHOR

COPYRIGHTED, 1927, BY EDWARD DEAN ADAMS, NEW YORK

PRINTED IN U S A
BY BARTLETT ORR PRESS, NEW YORK

To

COLEMAN SELLERS

1827–1907

CHIEF ENGINEER

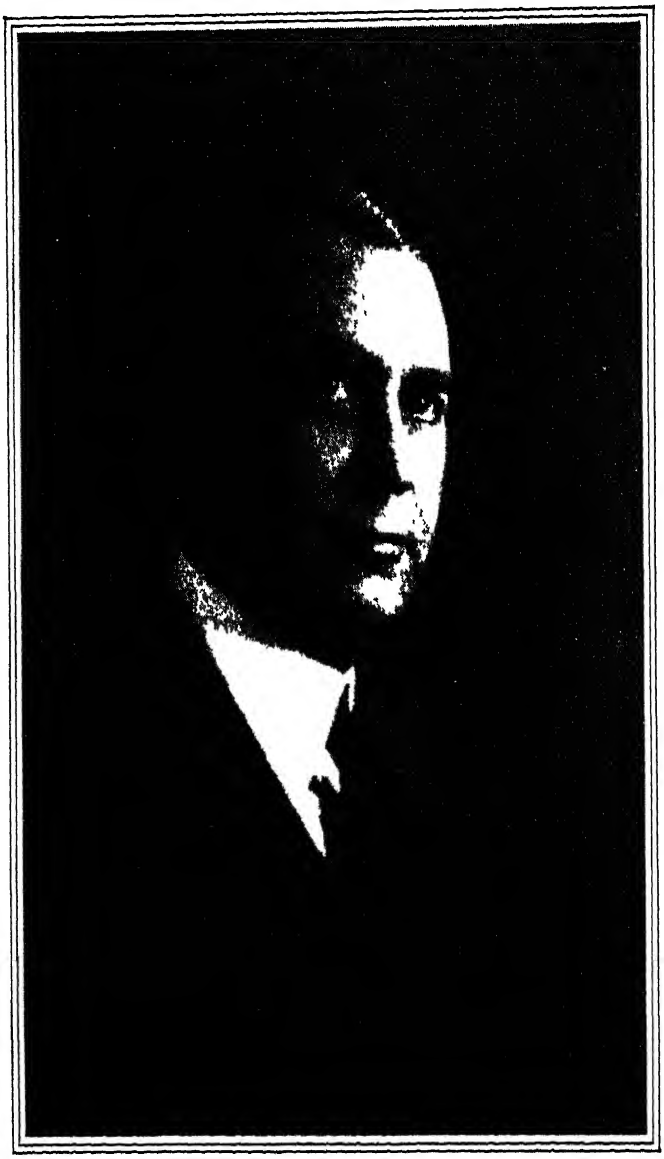
THE NIAGARA FALLS POWER COMPANY

THIS RECORD IS DEDICATED

BY THE AUTHOR

AS A TRIBUTE OF

HONOR AND AFFECTION



Paul A Schoellkopf

President, Buffalo, Niagara and Eastern Power Corporation

President, The Niagara Falls Power Company

A WORD OF INTRODUCTION

FEW developments have exerted so marked an influence in industry and commerce, and have made so great an impression in the art of generating and transmitting electricity, as those of The Niagara Falls Power Company.

The history of that company is related in these volumes by one who for thirty-eight years has given freely of his ability, time and influence towards the consummation of the enterprise. And how greatly has it expanded and what vast proportions has it attained!

When started thirty years ago, The Niagara Falls Power Company was the greatest hydro-electric enterprise in the world, with water turbines larger than any at that time in existence. Today, having kept step with the marvelous development of the art, it still retains that distinction as its latest water turbines are not only the largest but also the most efficient now in use.

The author of these volumes was for twenty years the president of The Cataract Construction Company which erected the original power stations at Niagara Falls and gave financial stability to the then Niagara Falls Power Company. He was intimately associated with every step in the development and personally sought out and interested the eminent international engineers whose counsel and advice were so helpful in the pioneer work. Well might he say with Virgil, "All of these things I saw, and a great part of them, I was."

It is pleasant to note in this connection that for his work at Niagara Falls, Mr. Adams was awarded the John Fritz Medal, the highest honor at the bestowal of the four senior national engineering societies of this country.

His was the directive force which brought the great project at Niagara Falls into fruition. No other man is more completely informed on its gradual and at times discouraging evolution, and it was in accordance with the expressed wish of his fellow directors that he undertook and completed the record contained in these pages.

For this, as for a vast amount of other voluntary services, Mr. Adams deserves the thanks of his fellow directors as well as of the electrical industry which has always manifested a lively interest in The Niagara Falls Power Company. As the president of that company I am conscious that I voice the

sentiment of my fellow directors and stockholders in this expression of grateful appreciation for all that Mr. Edward Dean Adams has done. He brought to his work broad culture and vast efforts. As a man his acquaintance and friendship are greatly treasured and highly prized.

THE NIAGARA FALLS POWER COMPANY

by Paul A. Schoellkopf Jr

President

"Books must follow sciences
and not sciences books"

Sir Francis Bacon, 1625

THE GREAT STEP IN THE TRANSITION FROM MECHANICAL POWER IN INDUSTRY TO ELECTRICAL POWER EVERYWHERE

THIS history of The Niagara Falls Power Company is the story of the development of the pioneer hydro-electric system, forerunner of modern utility power service. It records the great step in the transition from the century of mechanical power to the century of electrical power.

The event of the nineteenth century was the great adventure of the world in power, in manufactured power, from coal by the engine of Watt, or from the flow of falling rivers; mechanical power to replace muscular power; to pull trains and to drive machinery; to do miracles in industry by vast multiplication of the power the worker controls and thus to create a new epoch in human history. In the wake of power came industrial revolution, economic revolution, social revolution, and a readjustment of the philosophy and practises of life as the easier way of doing more created a new freedom from the immemorial bondage of toil.

Then came a great event in power production. It was at Niagara. Niagara—what other word conveys the same awe and sense of power! It was proposed to conserve the vast and wasting power of Niagara on a scale unprecedented.

But how? Did the water-wheels of centuries, or the water-powers of industrial New England or Switzerland point the way? Hydraulic experience and prevalent practise—mills driven by water-wheels—were inadequate for the new magnitudes and new conditions.

Could power be transmitted in large amount and over long distances, and how?

In 1890 the world experts studying the Niagara power problem advocated transmission by wire rope, by water pressure, by compressed air, by electricity. Electricity seemed immature. Edison and Kelvin recommending, said, "electricity, direct current." Westinghouse planning, said, "alternating current, but not now."

Electric systems were of many kinds; incandescent lighting near the source used direct current; more remote, alternating. Each small group of arc lamps

required a separate dynamo. Street cars used a different current. Motor service was trivial, supplied usually from lighting circuits. A world-wide search found little use of electricity except for local lighting. Here and there longer distance lighting or motor operation was found, but the methods were unsuited to a comprehensive system. A dynamo of one or two hundred horse-power was respected; very few were larger. Water-wheels of 500 horse-power were few and larger ones rare. But all of these were inadequate. A projected demonstration of a hundred horse-power or more, to be transmitted a hundred miles, inspired hope.

Then a gigantic thing happened. At Niagara a new method in power was evolved. The biggest power production enterprise in history was undertaken. The old-time driving of a mill by its water-wheel was discarded for concentrated production of power, of power sufficient for a hundred mills and more, although it was still undecided whether it would be transmitted by compressed air or by electricity.

Large power ideas and electrical development happily advanced together and out of the chaos of electrical practises and ideas of 1890 speedily came a great plan, a great step, *the* great step in the transition from the old to the new. It was the unprecedented production of power at one central station; it was the adoption of electricity in a power (not lighting) project, jumping from machines of a few hundred horse-power to units of 5000 horse-power in a 200,000 horse-power project.

Against the counsel of world-famed experts, polyphase alternating currents were adopted. Heterogeneous "systems" and circuits were replaced by one comprehensive system for universal service.

Many elements were brought together—the Great Falls of Niagara, long a barrier to transportation and contributing little to useful achievement; mechanical power and industry, increasing through a century; turbines, evolved from primitive water-wheels; electricity, rapidly maturing; electro-chemical processes, newly discovered. By scientific study and engineering planning and sturdy financial management, all these separate acts in the drama of hydro-electric power suddenly merged in one great climax, the pioneer modern power system.

And without halt or falter this pioneer plan has been followed in hydro-electric practise and in steam-power development as well. The power systems of the world today and the superpower systems planning for the future employ large central stations and polyphase alternating current.

At Niagara the great step was taken in the transition from the epoch-making century of local mechanical power to the new era of universal electrical power, assuring to the twentieth century an advance over the nineteenth comparable to that which the steam engine gave the nineteenth century over the preceding centuries.

Niagara contributes both energy and materials; she sends streams of silent power over radiating circuits to a million users; she supplies new materials from the electric furnace to serve the world.

But beyond the marvel in magnitude and methods and results reckoned in kilowatts and dollars are new achievements to be measured in human values.

Electric power becomes the universal servant to do the work of the world and to illumine its darkness, contributing to health and wealth and comfort—to the progress of civilization.

The story of Niagara power in the early nineties is the story of a persistent quest for an adequate way to use its waters, and of a momentous triumph in the age-long conquest over nature, for the Niagara adventure has shown how to make power of greater service by multiplying the fruits of toil and creating a new freedom for the development of the intellectual, the æsthetic and the spiritual life of mankind.

And the man whose genius planned this marvelous quest and whose patient and skillful co-ordination of mind and men and money achieved this miracle of success was Edward Dean Adams.

Chas F Scott

THE MANDATES

I. CONSOLIDATION (A WAR MEASURE)

IN November, 1917, the Secretary of War addressed the Hydraulic Power Company of Niagara Falls and The Niagara Falls Power Company, as follows:

> The President of the United States, by virtue of and pursuant to the authority vested in him, and by reason of exigencies of the national security and defense, hereby places an order with you and hereby requisitions the total quantity and output of electric power which is capable of being produced and delivered by you.
>
> You are directed to make immediate and continuous delivery of such power, in accordance with the schedules hereto attached, until further notice.
>
> This order shall be given precedence over any and all orders and contracts heretofore placed with you.

To facilitate these plans, the War Department requested the two companies to consolidate. A joint agreement of consolidation executed September 20, 1918, was approved the following month by the Public Service Commission of New York State. The new company assumed the outstanding bonds and other obligations of the constituent companies and by exchange of shares the

Hydraulic Power Company of Niagara Falls (Canal Project of 1853)
and The Niagara Falls Power Company (Tunnel Project of 1886)
consolidated as The Niagara Falls Power Company, MCMXVIII

II. THIS HISTORY

In view of the historical developments by The Niagara Falls Power Company, its retiring directors felt that there should be a suitable record of its epoch-making achievements. At their final meeting on September 20, 1918, the president stated that Edward Dean Adams, because of his great sentiment for and long association with the enterprise, could probably be persuaded to undertake the task and upon motion by Francis Lynde Stetson and Ogden Mills it was

> Resolved: That the thanks of the board be extended to Mr. Adams for consenting to prepare the history, which he is specially competent to prepare and which will be so greatly appreciated by the board; and that the president be and hereby is authorized to have the same printed and a copy thereof sent to each stockholder.

HISTORY AND POWER PROJECTS

Volume One

CONSTRUCTION AND OPERATION

REVIEWS AND REFLECTIONS

Volume Two

CONTENTS

Volume One

EARLY NIAGARA HISTORY AND POWER PROJECTS

EVOLUTION OF THE NIAGARA FALLS POWER COMPANY

RELATED AND ASSOCIATED COMPANIES ORGANIZATION—FINANCE

APPENDICES

LIST OF ILLUSTRATIONS

EARLY NIAGARA HISTORY
AND POWER PROJECTS

EARLY HISTORY OF NIAGARA

CHAPTER I

Seneca Names

NIAGARA

(NEAR-GAR')

GREAT FALLS

AND THEIR VICINITY

(GAR-SKO-SO-WAR-NEH)

AND

HIGH FALLS

(DATE-GAR-SKO-SASE)

EARLY HISTORY OF NIAGARA

CHAPTER I

PIONEER EXPLORERS

THE falls of the Niagara River have, from the time of their discovery, been recognized as one of the most impressive natural features of the world. For more than three centuries, visitors have come to them from every land, and left their tributes of admiration.

The first historical report of the existence of the Great Lakes, which pour their waters down the falls of Niagara, was very briefly made in 1545 by Jacques Cartier, the French explorer, in his account of his voyage of ten years before, when he ascended the river St. Lawrence to the site of Montreal. He credits the Indians for information given him of the existence of vast lakes, but does not mention the waterfall between two of them.

JACQUES CARTIER[1]
1491–1557

The earliest reference to Niagara Falls in all literature is found in that of France under date of 1604, when Samuel de Champlain recorded in *Des Sauvages* what the Indians on the St Lawrence River had told him about this waterfall, which, however, it appears that he had not then seen.

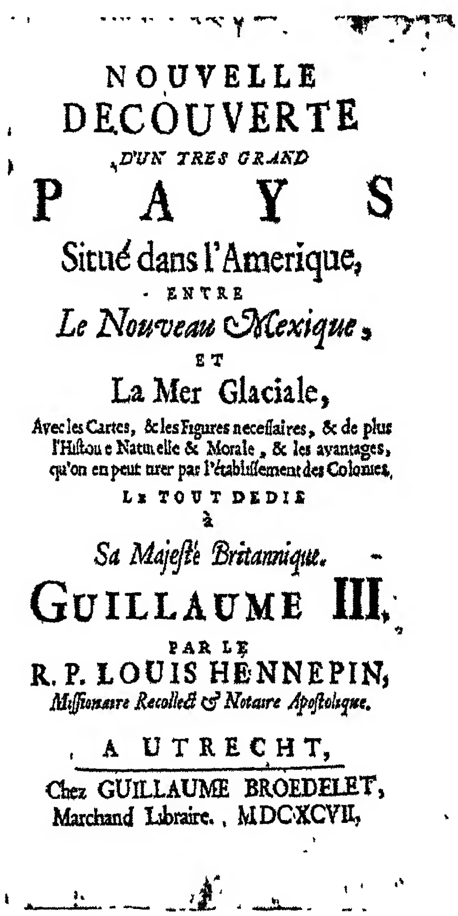
In describing a later voyage (1610), Champlain tells of having given a young Frenchman, Etienne Brule, to the Algonquin Chief, Iroquet, who showed his appreciation of Champlain's confidence by the gift of a young savage named Savignon, as a pledge of future friendship. By reason of his acquaintance with many tribes, of his occupation and his travels, there is no one who is more likely to be entitled to the distinction of having been the first of the white man's race to behold Niagara than this Etienne Brule.

SAMUEL DE CHAMPLAIN[1]
1567–1635

Champlain and Brule are thus two names of surpassing interest in the history of Niagara. The first unquestionably heads the long list of authors who have written about the great waterfall, while the other was possibly the first of the many millions of palefaces who have visited it.

[1] Lamb's *Biographical Dictionary of the United States*, Boston, 1900.

The missionaries from the Catholic Church in France, with headquarters in Quebec, established a mission to the Huron Indians. Their report in the *Jesuit Relation*, published in 1649, mentions Lake Erie, which "discharges itself in Lake Ontario over a cataract of fearful height." Dr. Gendron, Father Ragueneau and Father Bressani were all members of the Huron Mission between 1643 and 1652. In 1644 or 1645, Dr. Gendron used the words just quoted in a private letter to a friend in France, but it was not published until 1660. Father Ragueneau used the same words in the *Jesuit Relation*, published in 1649, and Father Bressani also used them in the *Relation* published in 1653.

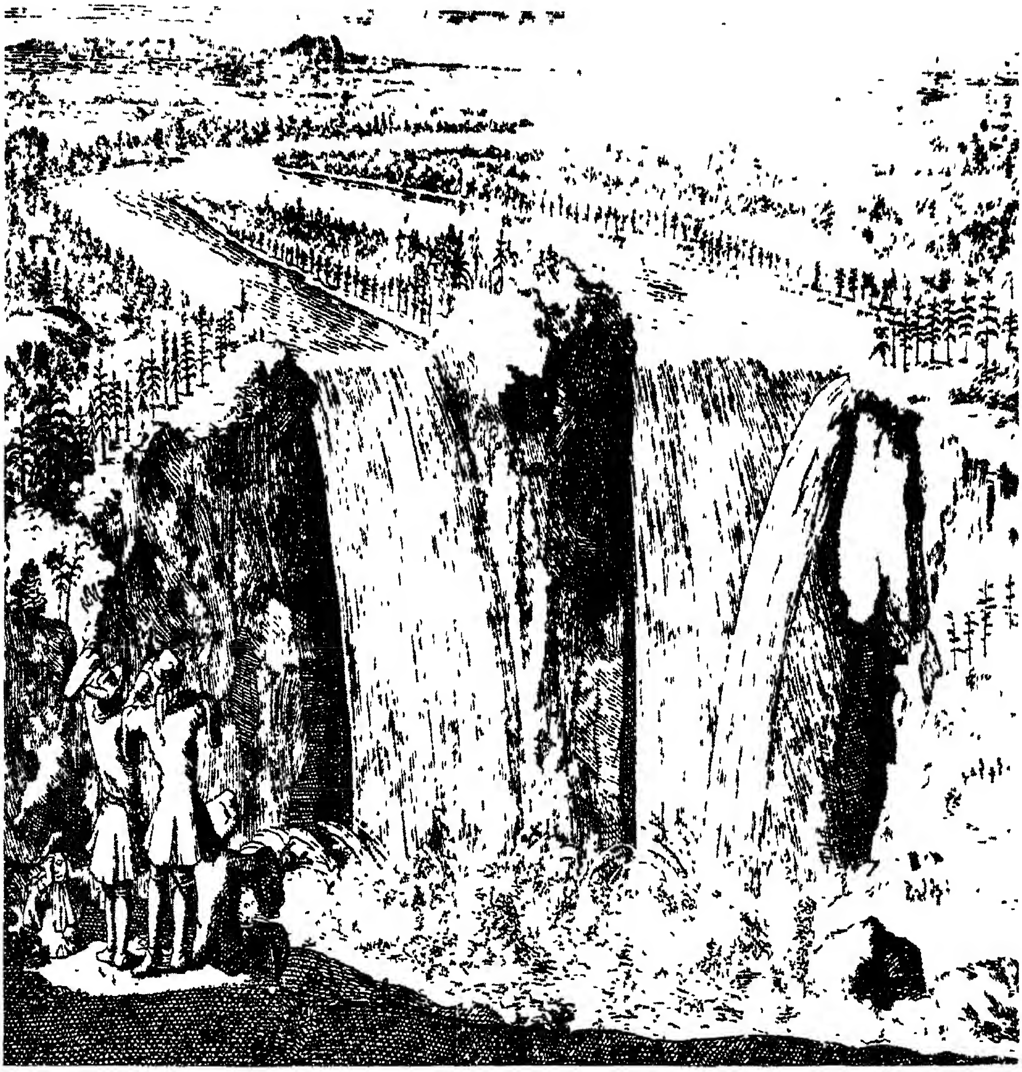

NOUVELLE
DECOUVERTE
D'UN TRES GRAND
PAYS
Situé dans l'Amerique,
ENTRE
Le Nouveau Mexique,
ET
La Mer Glaciale,
Avec les Cartes, & les Figures necessaires, & de plus l'Histoire Naturelle & Morale, & les avantages, qu'on en peut tirer par l'établissement des Colonies,
LE TOUT DEDIE
à
Sa Majesté Britannique.
GUILLAUME III,
PAR LE
R. P. LOUIS HENNEPIN,
Missionaire Recollect & Notaire Apostolique.
A UTRECHT,
Chez GUILLAUME BROEDELET,
Marchand Libraire. MDCXCVII.

The next name to become associated with Niagara is that of Robert Cavelier de La Salle, who explored the river and visited the falls in 1669, and, ten years later, built and owned the *Griffon*, the first commercial vessel of the upper lakes, thus becoming the father of their commerce.

For the earliest description of the falls we turn to the following report of Father R. P. Louis Hennepin, written upon his visit in 1679 and published in Utrecht in French in 1697, and in London in English in 1698:

> A description of the fall of the river Niagara, which is to be seen betwixt the Lake Ontario and that of Erie.
>
> Betwixt the Lakes Ontario and Erie, there is a vast and prodigious Cadence of Water which falls down after a surprising and astonishing manner, in so much that the Universe does not afford its Parallel. 'Tis true, Italy and Suedeland boast of some such things; but we may well say that they are but sorry Patterns, when compared to this of which we now speak.

To Hennepin we are indebted also for the first picture of the cataract, in the same publication, and reproduced in this chapter.



Niagara Falls in 1678

as seen and represented by

Father Hennepin

Print dated 1697

(From "Nouvelle Decouverte d'un tres grand Pays" by R. P. Louis Hennepin, 1697, a copy owned by the author, the title-page of which is shown on the facing page)

INDIAN NAMES

The relative position of the falls was correctly indicated on the maps of 1612 and 1632, printed upon the authority of the French explorer, Champlain, but no record of their name is found until 1656, when they appear on Sansom's map as "Ongiara." Hennepin's map of 1683 first gave them their present name "Niagara," while a map of 1692, published in Willard's history of the United States, shows them with the title "Jagara."

ROBERT CAVELIER DE LA SALLE
1643–1687

Brigadier-General Ely S. Parker, in 1892, stated with regard to the word Niagara:

> The name was originally applied to the whole river from Lake Erie to Lake Ontario, but as the old French fort at its mouth became of importance at an early date, the name was, and is still, applied to that locality, though the river has never lost its designation.
>
> The High Falls are known as "Date-gar-sko-sase" and the Great Falls and their vicinity as "Gar-sko-so-war-neh."

BRIGADIER-GENERAL
ELY SAMUEL PARKER[1]
U. S. ARMY
1828–1895

The pronunciation of the word Niagara was modified from Near-gar′ to Ni-a-gä′-ra when introduced by the early French explorers, in accordance with the usual accentuation in the Latin tongues; and the further modification to Nī-ăg′-a-ra naturally followed and still persists in English-speaking

[1] Ely Samuel Parker, soldier, a full-blooded Seneca Indian, Chief of the Wolf and Seneca tribes and the last Grand Sachem of the Iroquois, who held the honored office of "Do-ne-ho-ga-wa" (Keeper of the Western Door) was born in the Indian Reservation at Tonawanda, New York, in 1828. His Indian name was Ha-sa-no-an-da. He was successor and "grandson"[2] of "Red Jacket" as Chief of the Confederacy of the Six Nations: the Mohawk, Cayuga, Oneida, Onondaga, Seneca, and Tuscarora. He died at Fairfield, Connecticut, August 30, 1895. He was educated at public school and took an engineering course at Rensselaer Institute, Troy, New York, and studied law. He served with the United States Engineer Corps before Vicksburg, May, 1863, when he was commissioned aide-de-camp and military secretary on the staff of Lieutenant-General U. S. Grant, with rank of Colonel. He was commissioned Brigadier-General of United States Volunteers, April 9, 1865, "for gallant and meritorious services during the campaign, terminating with the surrender of the insurgent army, under General R. E. Lee, at which he was present." He retired as Brigadier-General U. S. Army, March 2, 1867. He served as United States Commissioner of Indian affairs, 1869–1871, and then resumed his profession of civil engineer in New York City.

[2] Buffalo Historical Society, Vol. VIII and Vol. XXIII.

countries, although various attempts have been made to revert to the historically correct and more beautiful pronunciation Nī-a-gä′-ra.

The directors, officers and engineers of The Niagara Falls Power Company were encouraged to use the native pronunciation. It was an interesting novelty in speech, but it was not understood, and the would-be students of the Seneca tongue tired of explanations and gradually avoided that necessity by adopting the customary pronunciation. An English engineer, who used the Seneca pronunciation when purchasing his ticket at the office of the Grand Central Station in New York, asked for "one ticket to Near-gar′." The agent did not appear to notice the request. Again the request was made, and the agent replied, "There is no such place on the New York Central System. Please move on." The Englishman responded, "I know better. I have been there. Well, then, give me a ticket to Nī-ăg′-a-ra, as you very improperly pronounce it, sir!"

PHYSICAL FEATURES: ACCESSIBILITY OF NIAGARA

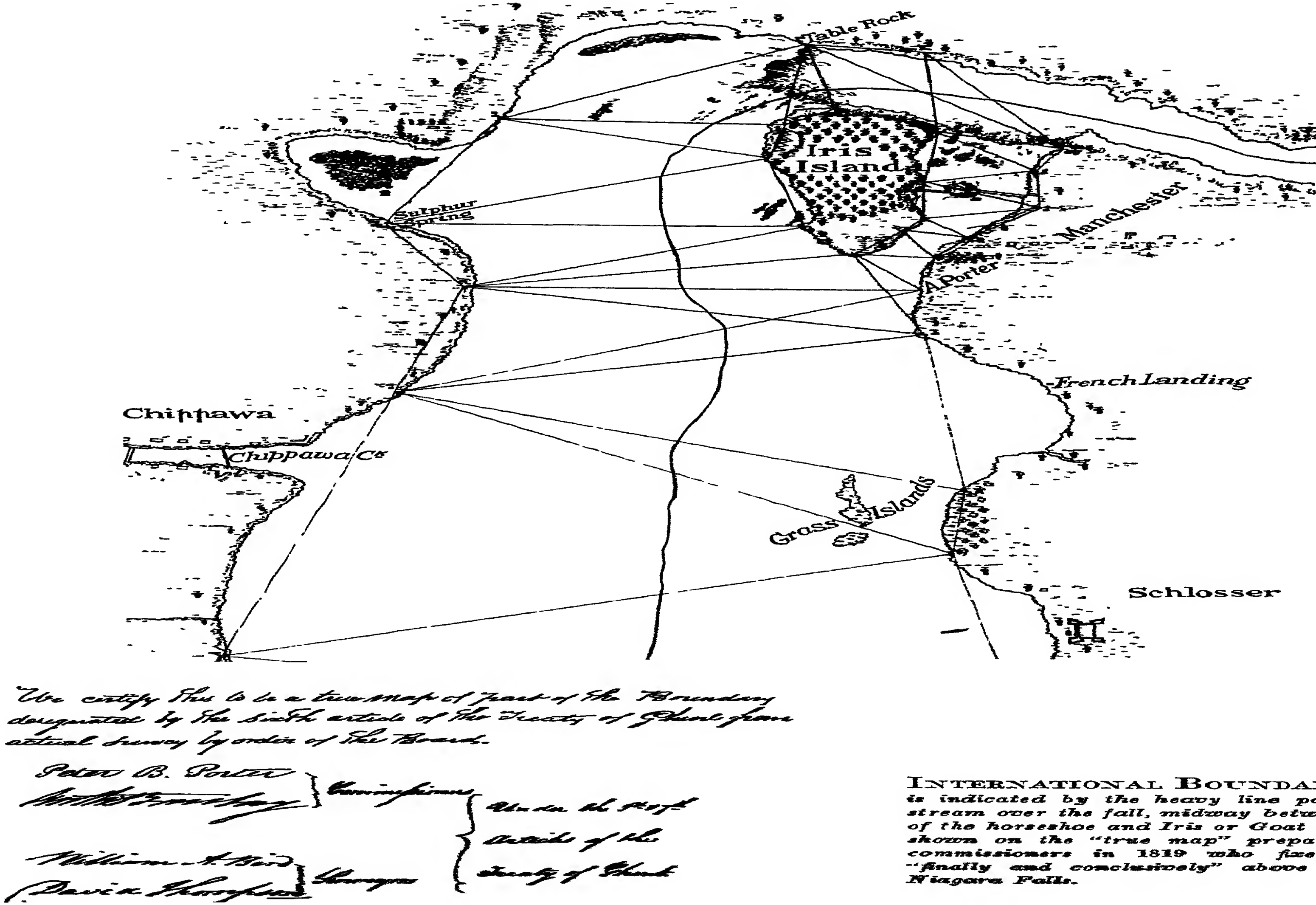
As a site for the development of water-power, the falls of Niagara stand without a rival in all the world. The lover of the sublime in nature might choose from among the world's majestic spectacles of moving water a few other great cataracts deserving of a place beside Niagara. Central Africa has the Victoria Falls of the Zambezi, and South America the great Sete Quedas of the Parana, the Iguassu and the beautiful Kaieteur. But these are all remote from large centers of civilized life, if not actually in the depths of the jungle, and all located in tropical regions which have never been favorable to occupation by the white race. Niagara, on the other hand, enjoys the temperate climate which has fostered every progressive civilization throughout history.

As for accessibility, to say that Niagara is not isolated like its rivals of the tropics, would be quite inadequate. It occupies a truly strategic position upon one of the great trade routes of the continent. The importance of this location from the earliest times is well recognized by Peter A. Porter[1] in his *Niagara an Aboriginal Center of Trade:*

> Niagara, in aboriginal days, was then, as it is now, the geographical center of the eastern one-third of North America; it was the center of population among the many and widely distributed Indian tribes; it was the most accessible, the most easily reached place from all directions in America. Indian trails led toward it from all points of the compass, it was easily accessible by water from every quarter.

This important position has never been lost; it has, indeed, been strengthened by the growth of cities and the building of roads and railroads. The

[1] Deceased, December, 1925.



International Boundary Line is indicated by the heavy line passing midstream over the fall, midway between the toe of the horseshoe and Iris or Goat Island, and shown on the "true map" prepared by the commissioners in 1819 who fixed the line "finally and conclusively" above and below Niagara Falls.

footprints of the white man, like those of the red, have converged more and more toward Niagara.

INLAND SEAS

In another fundamental respect Niagara is favored over other great cataracts mentioned. The reservoir capacity of all these latter streams is meager, resulting in such variations of flow from season to season that the continuous power available for practical development is thereby greatly reduced.

These conditions contrast sharply with those at Niagara, where four great lakes, or inland seas, unite to form a series of reservoirs having the stupendous capacity that may be expressed as several thousand cubic miles, but cannot be even approximately estimated because the work of determining the depths of the larger lakes has not yet been completed, and the few scattered soundings in the deeper portions show that the bottoms are extremely irregular. Lake Superior alone is the largest body of fresh water in the world. If this vast reserve of water could be gradually exhausted by drainage, it would be sufficient, without additional rainfall, to continue the present flow of Niagara for one hundred years. These reservoir lakes, or seas, cover an area of 87,620 square miles, and, with their connecting rivers, have a shore line of about 8300 miles.

Notwithstanding the enormous storage capacity of these inland seas, their value for power purposes is dependent upon their overflow and this is based upon the rainfall upon their surfaces and the run-off from the drainage basin of the Niagara River, that comprises an area of about 250,000 square miles, equivalent to the combined areas of states of New York, New Jersey, Pennsylvania, Ohio, Indiana and about one-quarter of Illinois. About 35 per cent of the water that falls as rain upon this great expanse of territory passes over the falls of Niagara. Uniformity in the rate of flow is assured by the great area of the lakes which serve as reservoirs—87,620 square miles.

INTERNATIONAL BOUNDARY LINE

The international boundary line at Niagara Falls is invisible, and only correctly indicated, even in public documents, when reproduced from the map attached to the official example of the Treaty of Ghent, of 1814, between the United States and Great Britain, which ended the War of 1812, and is on file in the office of the Secretary of State in Washington.

This map was prepared from an actual survey made by order of the board, Peter B. Porter and Anthony Barclay, commissioners, and bears their certificate that it is a true map of part of the boundary designated by the sixth article of the Treaty of Ghent.

This survey was made in 1819 and established the boundary line "through the middle of Lake Ontario until it strikes the communication by water between that lake and Lake Erie, thence along the middle of said communication into Lake Erie." By agreement of the commissioners, the line of demarcation in the Niagara River was the center of the deepest channel of the river's flow and the map and its signed declaration fixed the international boundary line "finally and conclusively."

In the report and map of recession-lines of the falls prepared in 1896 by Joseph W. W. Spencer, under a commission from the Director of the Geological Survey of Canada, it is stated that:

> The international boundary line, showing the Greater Falls to be in Canada, has been laid down on the map.
>
> Beside the other scientific results, features bearing on international questions have arisen in connection with the effects of the draining of the falls at the international boundary, and the lowering of the lakes by power diversions, as also the ownership of the water-rights of Niagara Falls
>
> Even the establishment of the boundary line at the falls comes to be a geological question and not merely one of ordinary surveying.

Professor Spencer states that "the apex of the falls (Canadian) is now (1906) estimated about 400 feet west of the boundary line, thus placing the crescent within the Canadian territory."

The international boundary line is the line of separation shown on the certified treaty map. The horseshoe deep water channel may move easterly toward Goat Island on the American side, but the international boundary line remains as "finally and conclusively" shown on the "true map" of the commissioners' survey.

LAND TITLES

Prior to 1600, the ownership of the land on each side of the Niagara River, including Goat Island and its group of smaller islands at the Great Falls, was undoubtedly in the Kaw-quaws, or Neuter[1] Nation of Indians. The Seneca Indians subsequently took possession and claimed the title to these lands by conquest from the Neuters, whose tribe they had destroyed.

The falls of Niagara were successively in the possession of the Indians by inheritance, the French by discovery, the English by conquest, the American colonists by revolution, and the State of New York by cession, treaty and purchase, the last two including the American Falls and part of the Horseshoe Fall.

France and England each asserted her rights to the locality, France by virtue of prior explorations, discovery and occupation, and England by virtue

[1] As named by the early French missionaries, meaning peaceful.

of the discoveries of her early navigators and of later treaties with the Indians. Until 1764, the Indian ownership was recognized by both France and England. French influence prevailed from 1669 to 1759; then the English acquired the property, which they occupied until the close of the Revolution and after, until 1796. The title to the islands remained in the Senecas until they ceded it to the State of New York in 1815.

POWER SURVEYS

The record of the successive instrumental surveys that have been made of the flow of these waters, to determine its quantity and potential value, from 1841 to 1924, is of historical interest.

The earliest calculation of the volume of water and the extent of the motive power of Niagara was made in 1841 by the engineers, Zachariah Allen, of Providence, Rhode Island, and E. R. Blackwell, of Black Rock, New York. From their measurements at Black Rock, near Buffalo, as published, they calculated by the formula[1] established by Eytelwein, the flow of Niagara River as 374,000 cubic feet per second. Upon this basis, and taking the height of the fall at 160 feet, Allen estimated the "mechanical force or motive power" that the waterfall of Niagara is capable of imparting, as 4,533,334 horse-power, after allowing one-third part for waste of effective power in the practical application of water to water-wheels. The initial power is therefore approximately 6,800,000 horse-power.

The U. S. Army engineers on the survey of the Great Lakes, in 1868 estimated the total available power of Niagara Falls at about 6,000,000 horse-power.

From measurements made in 1900, John Bogart, New York State engineer and surveyor, gave the flow of Niagara as 275,000 cubic feet per second.

The figure given in 1901 by the United States Geological Survey for the average flow is 222,000 cubic feet per second.

The report of Francis C. Shenehon, principal assistant engineer, United States Lake Survey, 1906–1907, includes the following statements regarding the Great Lakes and Niagara River:

> The drainage area covers 255,000 square miles, of which 59.4 per cent, or 151,500 square miles, lies on the American side of the international boundary lines.
>
> The annual rain and snowfall over this watershed amounts to nearly 31 inches of water. The outflow spilling from Lake Erie into the Niagara River corresponds to a depth of about 11 inches spread over this great drainage area of more than a quarter of a million of square miles.
>
> At an ordinary or mean level of Lake Erie, the flow of the Niagara River is about 210,000 cubic feet per second. Were all this water utilized under a head of 202.4 feet

[1] Long since replaced by formulæ considered of greater accuracy.

(which is close to the head secured by The Niagara Falls Hydraulic Power and Manufacturing Company), the theoretical mechanical horse-powers would aggregate nearly 5,000,000 (4,830,000).

Lieutenant-Colonel C. S. Riché, of the United States Corps of Engineers, reported September 30, 1911, that for mean stages of lakes Erie and Ontario, 1860–1910, Niagara River had a total fall of 326.38 feet and a discharge of 210,000 cubic feet of water per second, which represents a theoretical energy of nearly 8,000,000 horse-power.

The volume of Niagara waters depends upon the height of Lake Erie at Buffalo, and this varies with the direction and intensity of the wind. A prolonged gale on Lake Erie in the direction of its outlet causes the waters to become heaped up at that end from 4 to 5 feet and produces a corresponding rise of Niagara River. A subsidence of the level of the lake and river to an equal extent occurs whenever a gale takes place in an opposite direction. Such variations are not uncommon, and have been brought about in the course of a few hours. Changes in level of Lake Erie at the source of the Niagara River of as much as 8 feet have been noted. On March 29, 1848, the floating ice in Lake Erie was driven by the gale to the lake outlet, quickly blocking that narrow channel and shutting off a large proportion of the river's flow. The American Falls were passable on foot, but for that day only, as is described by an eye witness, in Appendix F in this volume.

A change in elevation of 1 foot in Lake Erie will cause a change in elevation in the Chippewa-Grass Island Pool of about 55 foot.

The seasonal variation in lake level, due to variations in rainfall, has not exceeded 2 feet in the last sixty years.

In his testimony before the commissioners of the state reservation in 1884, Peter A. Porter stated that, when the wind is down the lake, it makes 1 foot difference in the level of the raceway on the rapids above the falls, increasing the depth to that extent.

These minor fluctuations of level are trivial in comparison with the seasonal changes of volume to which most of the great waterfalls of the world are subjected.

ESTIMATES BY VARIOUS AUTHORITIES 1841–1924

REFERRED TO ABOVE

Dates	Authorities	Cubic feet per second	Theoretical mechanical horse-power
1841	Blackwell and Allen, engineers using 160 feet head	374,000	6,800,000
1868	U. S. Army engineers on survey of the Great Lakes	273,329 to 280,757	6,000,000
1890	John Bogart, New York State engineer and surveyor[1]	275,000	
1901	United States Geological Survey[2]	222,000	
1906 to 1907	United States Lake Survey, report of Colonel C. S Riché to chief of engineers[3] using full 326 feet head	210,000	8,000,000
1908	United States Lake Survey; Colonel F. C. Shenehon, principal assistant engineer[4] At mean level of Lake Erie using 202 feet head	210,000	4,830,000
1924	Smithsonian Institute, *Study of Natural Resources.* Samuel S. Wyer, associate in mineral technology, United States National Museum[5] Natural mean flow for sixty-four years using full 326 feet head	205,000	6,000,000[6]

[1] Seventh annual report of commissioners of New York State Reservation 1889–1890

[2] United States Geological Survey Map of Niagara River and Vicinity, G K. Gilbert, May, 1901.

[3] United States Lake Survey, *Preservation of Niagara Falls, 1911.* House of Representatives Document 246, Sixty-second Congress, Second Session, page 11.

[4] United States Lake Survey, Senate Document 105, Sixty-second Congress, First Session, page 20. An exhaustive investigation

[5] Smithsonian Institute, *Study of Natural Resources, Niagara Falls, January 15, 1925.*

[6] Horse-power which could be developed.

DIFFICULTIES IN POWER DEVELOPMENT

Situated on one of the great natural channels of commercial intercourse between the East and the West, it was not unreasonable to expect that with the improvement of the country, near and remote, the vast water-power would be

promptly utilized and the population proportionally increased. That this did not occur as rapidly as the early settlers had hoped was owing to causes not at first appreciated, but now well understood as briefly described here.

In order to understand some of the physical difficulties that for many decades prevented the utilization of the waters of Niagara, attention should be given to the unusual natural features of the location. These are indicated by the block diagram of Niagara River and accompanying maps and diagrams. The block diagram shows:

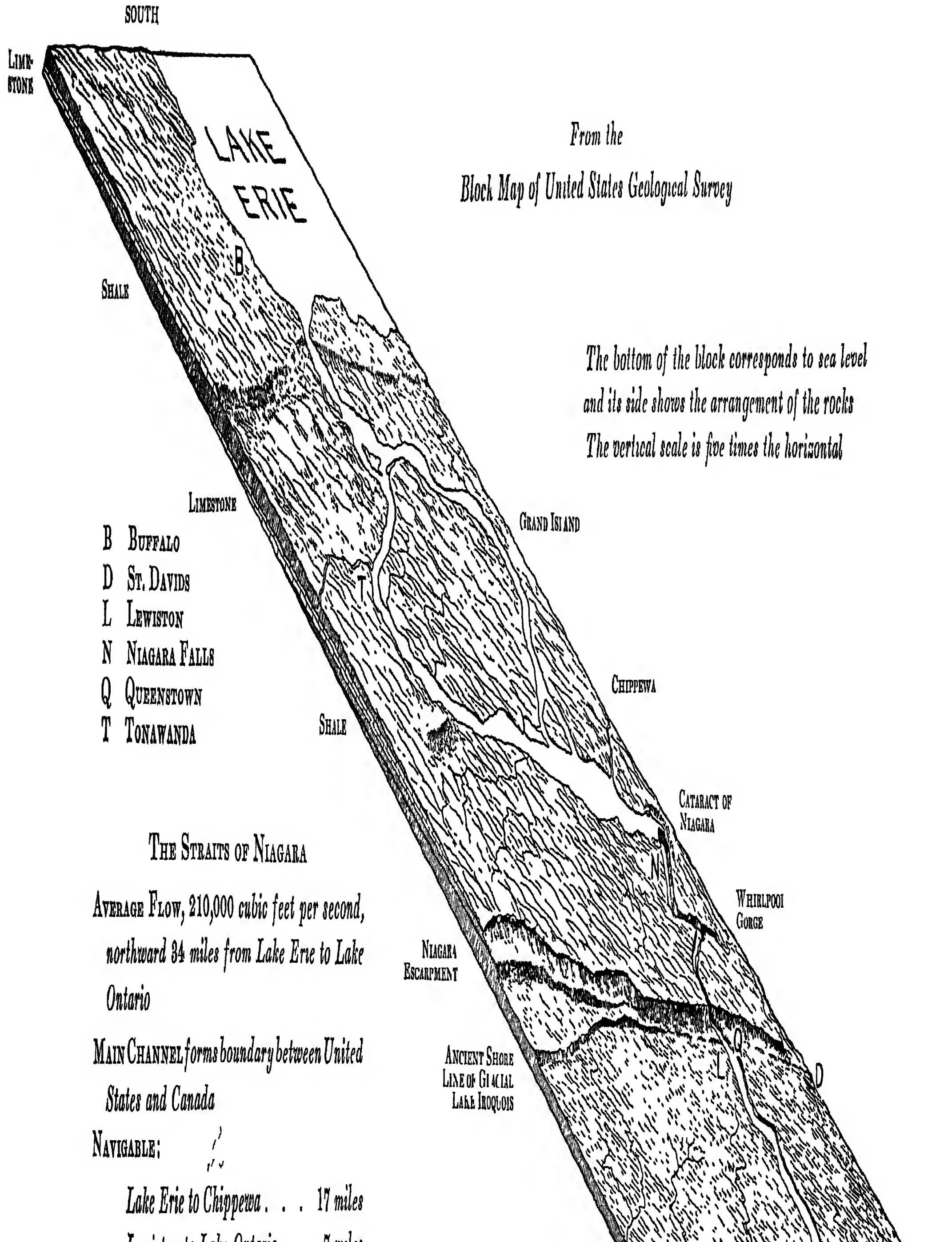
> The country traversed by the river constitutes two plains, each extending for a considerable distance east and west beyond the field of the map. The upper plain has a gently undulating surface with a general height of 600 feet above sea level. The lower plain borders Lake Ontario and is comparatively smooth except where streams have washed out narrow valleys: its southern edge has a height of 380 to 400 feet, and it slopes northward to about 260 feet at the lake shore. Where the plains approach each other the upper is about 200 feet above the lower and they are separated by a steep bluff with a cliff at top This bluff is called the Niagara escarpment. In some places it is divided into two parts, so that the descent from the upper plain to the lower is by two steps.[1]

A mile above the falls the river enters upon the great upper rapids, considered by many to present a spectacle no less impressive than that of the cataract itself. These rapids account for 51 feet of the descent, and the Great Falls for 164 feet.

Below the falls the river runs in the deep gorge which it has carved out of the upper plain. For some distance there is a navigable reach of deep water. The remaining 5 miles to the Niagara escarpment is almost continuous rapids, with the famous Whirlpool as the dominating feature. In its course below the falls the river descends 99 feet more to the level of the lower plain, where it flows in a broad, deep channel for the remaining 6 miles to Lake Ontario. The total descent in the upper and lower rapids and the falls is 314 feet.

Although the great cataract itself offers the most magnificent display of available power, the upper rapids, because of their low banks, lent themselves more readily to power development by the more primitive methods in which water diverted from the river above the rapids is carried by a canal along the river bank for use at comparatively low head to supply wheels driving mills or in which wheels placed in the stream are driven by the current. In tracing the history of Niagara power we are therefore not surprised to find these rapids the scene of the earliest and, in fact, of all the applications of power until about 1870, with mills along the main shore, or on the islands.

[1] G. K. Gilbert, 1901. From United States Geological Survey Map of Niagara River and Vicinity.



From the

Block Map of United States Geological Survey

The bottom of the block corresponds to sea level and its side shows the arrangement of the rocks The vertical scale is five times the horizontal

B Buffalo
D St. Davids
L Lewiston
N Niagara Falls
Q Queenstown
T Tonawanda

The Straits of Niagara

Average Flow, *210,000 cubic feet per second, northward 34 miles from Lake Erie to Lake Ontario*

Main Channel *forms boundary between United States and Canada*

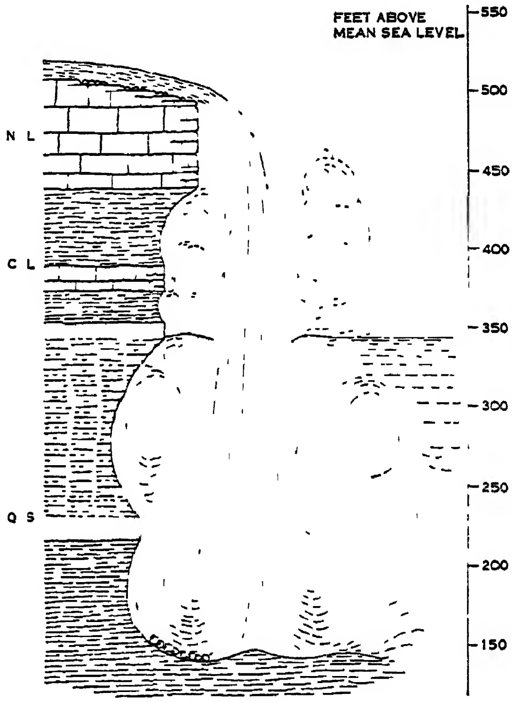
Navigable:

Lake Erie to Chippewa . . .	*17 miles*
Lewiston to Lake Ontario .	*7 miles*

Lake Levels Above Sea:

Lake Erie	*573 feet*
Lake Ontario	*246 feet*
Difference	*327 feet*

Serious difficulties were encountered when it was proposed to develop a large amount of power from the cataract itself. Large water-wheels for operation at a head of 160 feet or more were not available; even if they had been, the cost of hydraulic construction in the Niagara limestone formation would be very great; even if the power were developed, the old plan of a "mill over a wheel-pit" did not promise success because available land for factories in the vicinity of the falls was limited. Furthermore, no large amounts of power were used in the vicinity of the falls although there were large power users at Buffalo. The cost of power development was so large that only a very large project would be financially justified. Hence, the high head of the cataract was not availed of at once, but awaited the call for large amounts of power and the development of modern machinery and methods. The utilization of the total fall in the upper and lower rapids as well as the cataract, involving constructions of colossal magnitude, has received consideration only very recently.



SECTION SHOWING STRATIFICATION OF ROCKS AT THE BRINK OF THE FALLS AND AT MIDDLE OF HORSESHOE FALL DESCRIBED BY PROFESSOR GILBERT AS N. L., NIAGARA LIMESTONE, C. L., CLINTON LIMESTONE; Q. S., QUARTZOSE SANDSTONE

The scenic beauty of the great cataract made the situation still more difficult for those who wished to put the river to practical use. Sooner or later, the public was certain to resist any methods of utilization of the falls that encroached upon their natural grandeur. This consideration will be found to have been a very potent factor in shaping the course of the development of Niagara power and it is one of the supreme triumphs of that development that the utilitarian and aesthetic points of view have been so well reconciled.

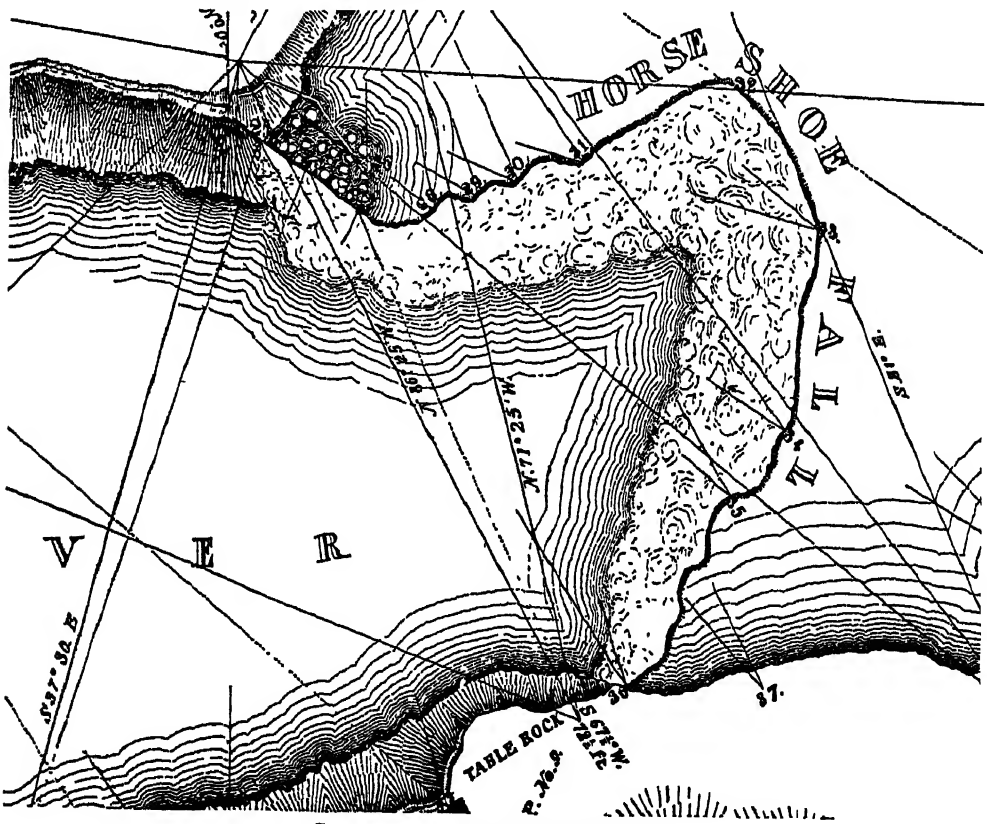
In the geological structure[1] of the Niagara region which has made possible the falls and the gorge will be found the source of many perplexing problems

[1] See Appendix B for extract from final report of the Fourth Geological District of the State of New York, 1843, by James Hall, state geologist, Chapter XX, *Niagara Falls, Its Past, Present and Prospective Condition*, pp. 383-404, with important illustrations.

that have arisen in every stage of Niagara development. The first rock encountered at the cataract is the hard, strong Niagara limestone, extending at this point to a depth of 80 feet. Below are soft, weak shales, containing only a few ledges of harder material. The history of Niagara shows how the development of power has been retarded by this combination of strata. We see the pioneer faced with huge expense in his endeavors to excavate surface canals and raceways through the hard limestone; while his successors, in order to preserve the hydraulic head obtained above the falls, were obliged to construct their discharge tunnel at the level of the lower river and pass into a material which could not be depended upon to form a safe and durable arch without costly reinforcement. The modern engineer, who obtains his hydraulic head on the bluff near the point of its utilization, has designed and built a pressure tunnel through the kind of rock best calculated to produce a permanent structure, with the least capital cost.

RECESSION OF HORSESHOE FALL

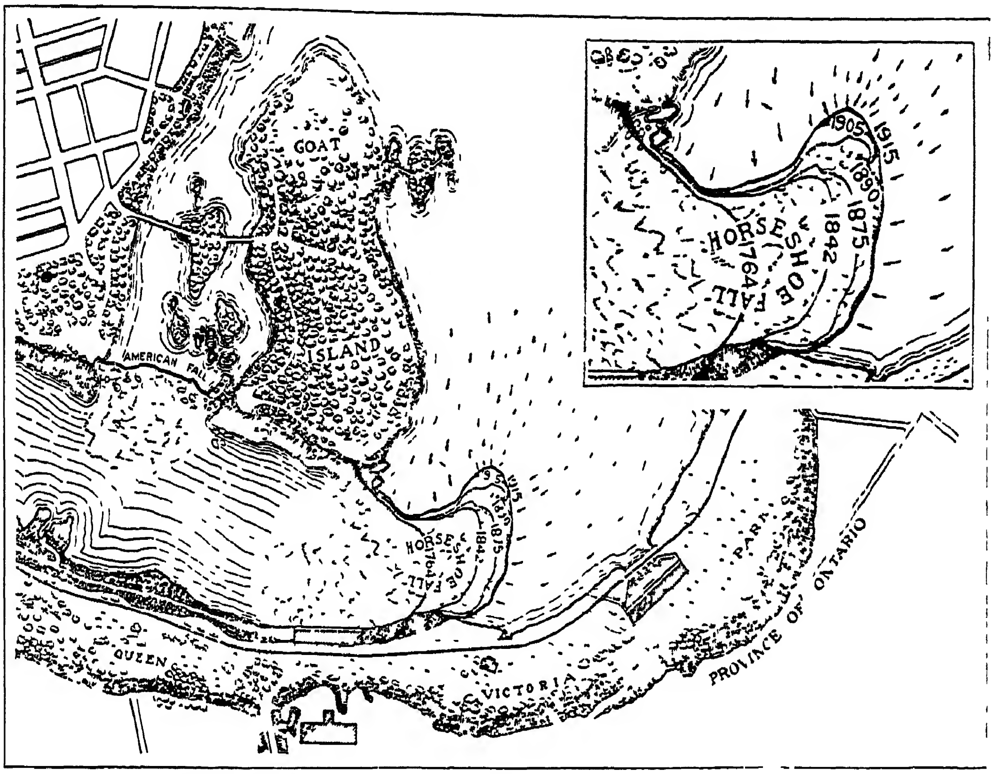
The progress of the recession of the Horseshoe Fall has been ascertained by various trigonometrical surveys under official auspices including the



SURVEY OF HORSESHOE FALL
1891
By John Bogart, New York State Engineer

following: 1842 by New York State Survey, 1875 by United States Lake Survey and 1891 by New York State Survey that is here reproduced.

The history of the formation of the horseshoe is shown by the following map:



From Harper's *Suicide of the Falls*

LENGTH OF CRESTLINE OF HORSESHOE FALL SHOWING RECESSION

1764 . . .	1800 FEET	1875 . .	2350 FEET	1905 . . .	2850 FEET
1842 . . .	2030 FEET	1890 .	2750 FEET	1915 . . .	3020 FEET

The recession of the falls is due to this peculiar rock structure which has received much attention in recent years, and which has a bearing upon power development. This process of disintegration is described by G. K. Gilbert, geologist, United States Geological Survey:

In the principal division of the cataract, called the Horseshoe Fall, the falling water plunges into a deep pool, which is kept in fierce agitation. The surging water wears away the shale and thus gradually deprives the limestone bed of its support. From time to time blocks of the limestone break away, falling into the pool below. Each fall of limestone makes the position of the cataract retreat upstream and thus lengthens the gorge. Between 1842, when a careful map of the cataract was made, and 1891, when the mapping was repeated, the cataract retreated and the gorge was lengthened about 200 feet, the

average rate being between 4 and 5 feet a year . . . But the crestline of the American Fall has not changed its form appreciably since the year 1827, when the first accurate drawings of it were made. Its recession must be many times slower than that of the Horseshoe Fall.

In its annual report of December 19, 1918, the commissioners of the New York State Reservation stated that the recession of the rock rim of the Horseshoe Fall is progressing at the rate of about 62 inches per annum.

An examination of old prints indicates that the present horseshoe formation of the Canadian side of the fall must have appeared after the year 1751, not

From a camera lucida drawing made in 1827 by Captain Basil Hall of the British Navy

THE HORSESHOE FALL

more than 174 years ago, as there are no indications in these views of any such crestline.

The "horseshoe" section of Niagara Falls is the best known feature of that scenic wonder. Its changing form excites the study of all visitors. They admire the dark green of its deepest current, and regret to read of the recessions that are chronicled and that they can visualize.

An interesting evidence of the recession of the Horseshoe Fall was reported by James T. Gardner,[1] in 1879, who placed the survey of E. R. Blackwell in

[1] Director of the New York State Survey of the Preservation of the Scenery around Niagara Falls.

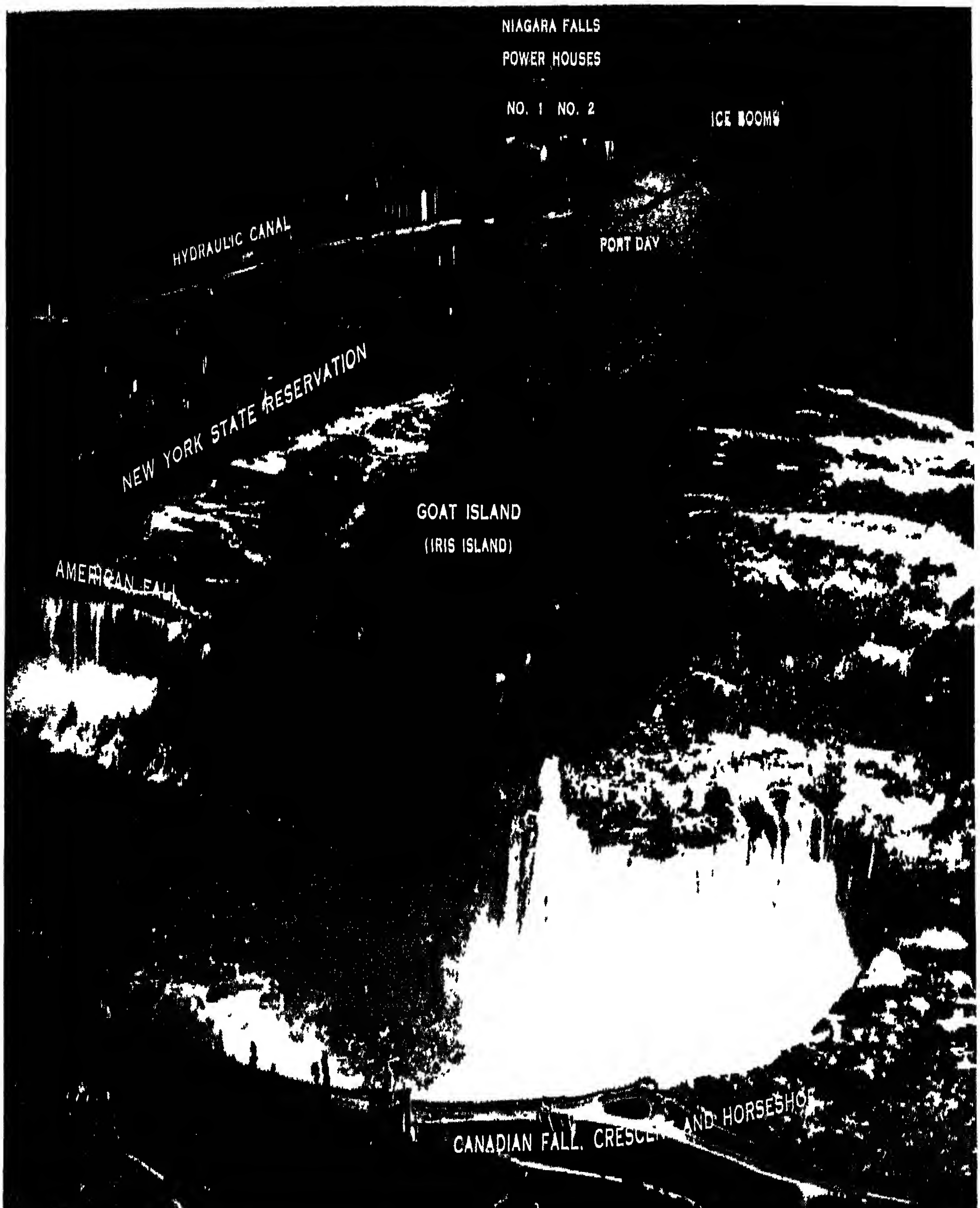
1842 upon the map of the United States Lake Survey of 1875 and describes the comparison as follows:

> The map which accompanies my report shows the unexpected fact that the Horseshoe Fall has receded in places 160 feet during thirty-three years, and that a large island has disappeared which formerly existed in the midst of the Canadian Rapids. These remarkable physical changes are of deep interest, and their progress should be watched and recorded with great care. The conclusions to be attained by accurate geological study of the region open almost limitless views into far-reaching vistas of the continent's physical history.

From actual observations made during the past ten years it is known, Mr. John Lyell Harper states, in his *The Suicide of the Horseshoe Fall, 1918,* that the crest is receding at the point of greatest erosion, at the rate of approximately 8 feet per year, while on the sides and heel almost no recession is noted.

SCALE MODEL OF NIAGARA FALLS PLANNED BY JOHN LYELL HARPER FOR EXPERIMENTS IN REMEDIAL WORKS AND STREAM CONTROL

Note crestlines of 1764 *and* 1842



AEROPLANE VIEW OF NIAGARA FALLS

Showing on the low banks of the upper river, power-houses, numbered one and two of The Niagara Falls Power Company, now its reserve plant. Below this plant is indicated Port Day, the entrance to the hydraulic canal

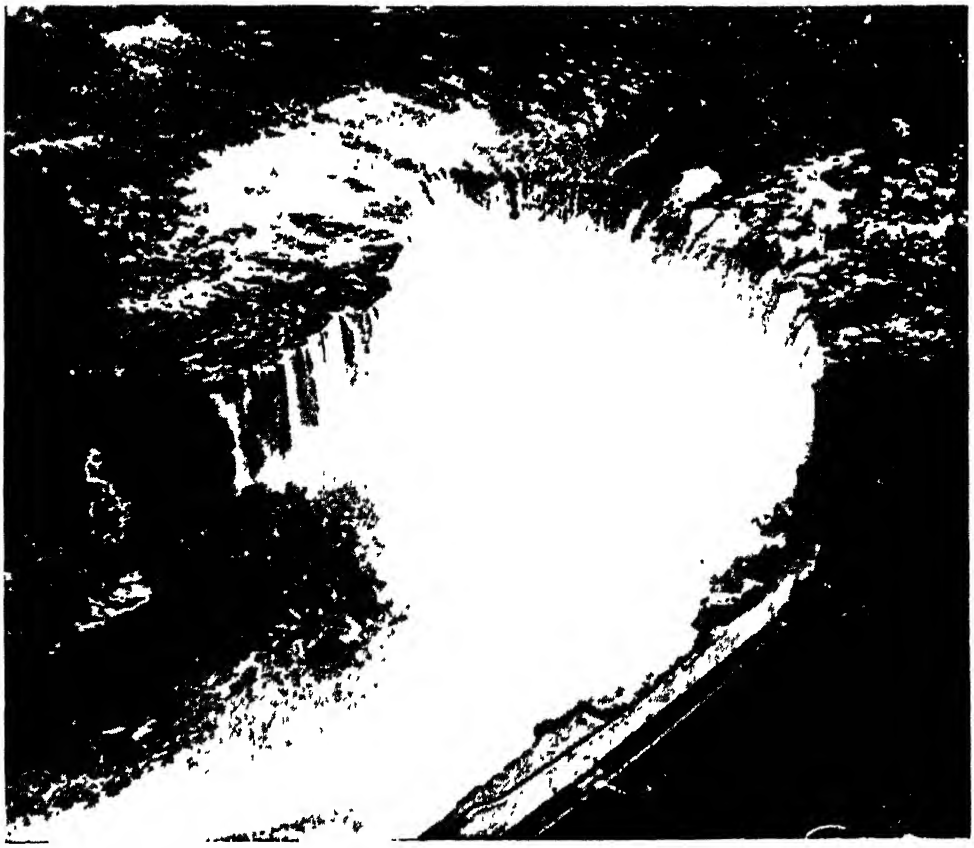
The main channel carries about 94 per cent of the water that passes over the cataracts, but this amount is unevenly distributed over the 3000-foot crest of the Horseshoe Fall Above 85 per cent of the total flow of this channel is concentrated in the middle third of the Horseshoe, resulting in the continuance of the recession, which since the survey of 1764 has caused a recession of the cataract up-stream for a distance of about 900 feet

VISION OF FUTURE CONDITIONS

Mr. Harper[1] in an article in *Power* states:

The ultimate development of Niagara Falls will have a 300-foot head, when each cubic foot of water per second will produce an amount of power capable of lifting a 100-ton burden one inch from the tired shoulders of man.

Engineering thought blazes the trail to the most efficacious use of Niagara's waters. This thought now takes form in action, and action removes the doubt that theory cannot



Photograph by Underwood & Underwood, N. Y., taken by Major H K Maxwell

AEROPLANE VIEW OF THE HORSESHOE FALL

Made October 20, 1920, at 700 feet elevation

solve. Results exceed the vision and now Niagara, more than ever, supplies the material wants of man.

With equal vision, skill and courage must engineering control that part of the waters which may be set aside for æsthetic purposes. Engineering must shape its turbulence, and so direct its cataract-forming currents that the maximum of grandeur may obtain. Engineering has made it possible to convert 90 per cent of the stored energy of Niagara's waters into useful forms of electrical power. Engineering can, and will, take but half the

[1] Vice-president and chief engineer of The Niagara Falls Power Company. Deceased, 1924.

river's flow and raise its æsthetic values to a level with the hydro-electric efficiency now obtaining. With half the water, engineering will enhance the natural beauty, and render a more sublime spectacle than Nature, uncontrolled, now furnishes with all of the water.

The annual report of The Niagara Falls Power Company, 1924, states concerning the scale model:

During 1923 and 1924 there was built, under Mr. Harper's direction, a scale model of the Niagara River including the upper rapids and the cataracts. Here experiments have been conducted in stream control. Remedial works of different types have been built upon the model to determine the increase that may be made in the economic utilization of Niagara while assuring the maintenance of its sublime scenery.

This marked recession is a factor to be reckoned with in the future in the location of expensive installations drawing water from the river above the falls. If, however, the recession continues at the rate of only about 5 feet per annum, the intake of The Niagara Falls Power Company, situated about 6000 feet above the cataract, would not be disturbed in its present location for about 1200 years.

There is also a very remote danger, geologists inform us, of a possible future diversion of water from the great Niagara reservoirs to the Mississippi River.

"With the present rate of calculated terrestrial uplift in the Niagara district (1.25 feet a century) and the rate of recession of the falls continued, or even doubled, before the cataract shall have reached the Devonian escarpment at Buffalo, that limestone barrier shall have been raised so high as to turn the waters of the upper lakes into the Mississippi drainage by way of Chicago. An elevation of 60 feet at the outlet of Lake Erie would bring the rocky floor of the channel as high as the Chicago divide, and an elevation of 70 feet would completely divert the drainage. This would require 5000 or 6000 years at the estimated rate of terrestrial elevation."[1]

[1] *The Duration of Niagara Falls*, Prof J W W. Spencer, 1895

EARLY HISTORY

POWER POSSIBILITIES

MAPS AND POWER DEVELOPMENT CHARTS OF THE GREAT LAKES, THE STRAITS AND FALLS OF NIAGARA, ALSO THE ST. LAWRENCE RIVER

1925

THE "MERE NON-USE OF THE WATERS OF NIAGARA FALLS IS NOT THEIR PRESERVATION"[1]

Dr. Charles D. Walcott, secretary, Smithsonian Institute, Washington, D. C., recently stated:

The Niagara River is more than a mere boundary stream between two friendly nations It is the dividing line between two radically different methods of rendering electric service to the public, governmentally owned on the Ontario side, privately owned but governmentally regulated on the United States side.

Two and one-half times more power than is now developed can be developed and still maintain an adequate scenic effect. Real preservation can be brought about only by frankly facing the engineering and geologic facts now obvious and the development of an international preservation program that will insure maximum use with the continued preservation of an adequate scenic effect

ADDITIONAL POWER THAT COULD BE DEVELOPED AND STILL MAINTAIN PROPER SCENIC EFFECT[1]

The natural mean flow—average of 64 years—of Niagara River, in cubic feet per second		205,000
Water diversions, in cubic feet per second—		
New Welland Ship Canal for navigation	2,000	
New York State Barge Canal for navigation	1,200	
Chicago Drainage Canal for sewage dilution	8,000	
Diversion for power purposes authorized by present treaty	56,000	
Diversions[2]	67,200	
Minimum flow over falls for proper scenic effect and ice sluicing	50,000	
Appropriations[2]		117,200
Additional[2] water that could now be harnessed		87,800

This water could develop about 2,500,000 additional horse-power This total might be curtailed for a few days each spring to give the extra water needed to sluice the ice out of the gorge.

The practical demonstration of the possibilities of protecting the Horseshoe Fall from its own destruction, and the increase of power resources without detriment to the scenic features of the fall, as recently proposed by John Lyell Harper by his operating out-door model, may be seen on page 27.

[1] *Niagara Falls: Its Power Possibilities and Preservation,* by Samuel S. Wyer, associate in mining technology, United States National Museum.

[2] Words are not italicized in the original.

DATA PERTAINING TO THE GREAT LAKES

From reports to the United States Government and other sources

The system of the great fresh water lakes or inland seas, which drain through the Straits of Niagara and the Saint Lawrence River into the Atlantic Ocean, extends half-way across the continent of North America.

The water surfaces of these great lakes, excluding Lake Ontario, with the land sloping into them and contributing to the falls of Niagara, form a drainage basin having a total area equal to nearly three times the total area of Great Britain and Ireland, about 50,000 square miles more than the total area of France, and more than sixteen times the total area of Switzerland

The work of determining the depths of the larger lakes has not yet been completed but the few scattered soundings in the deeper portions show that the bottom is extremely irregular.

The fall of 326 feet between the water levels of Lake Erie and Lake Ontario occurs in the vicinity of Niagara Falls and is distributed as follows.

	Feet
Lower Niagara River	1
Five miles of rapids, between Lewiston and Suspension Bridge	94
Pool between the bridge and the falls	5
Falls of Niagara	164
Rapids immediately above the falls	51
Upper Niagara River	11
Total fall of Niagara River between lakes Erie and Ontario	326

The Niagara River forms the boundary between Canada and the State of New York The line of this international boundary is that established by commissioners in 1819, as shown upon the map attached to the International Treaty of Ghent of 1814 and shown herein on page 15. The falls of Niagara are 23 miles below Lake Erie, and 14 miles above Lake Ontario. The "Horseshoe Fall" is 163 feet high, and 2600 feet wide. The other channel, in the State of New York, forms the "American Falls," which are 166 feet high at the eastern side, and 1000 feet wide, both falls comprising 3600 linear feet of water.

At the falls the river turns directly at right angle and flows through a gorge, the cliffs of which are 1000 to 1200 feet apart, with nearly perpendicular walls rising 210 feet above the water. The river below the falls has a maximum known depth of 192 feet, and a width of from 800 to 900 feet.

Two miles above the falls the river has a width of over 7000 feet. The extreme limits of variation in the depth of the river above the falls is 3½ feet, but these limits are very rarely reached. The ordinary variation is about 1 foot. Below the falls the extreme of variation reaches 15 feet. Generally a variation of 1 foot above the falls is followed by a change of level of 5 feet below the falls. These slight changes are of a short duration and are due mainly to long continued and violent wind or sudden great accumulations of ice.

It has been estimated that if the average discharge of all the lakes passed through a river 1 mile wide, with a mean velocity of 1 mile per hour, such a river should have a depth of 31 feet from shore to shore.

The flow of water at the falls of Niagara is, for practical purposes, unlimited, never failing. constant and pure.

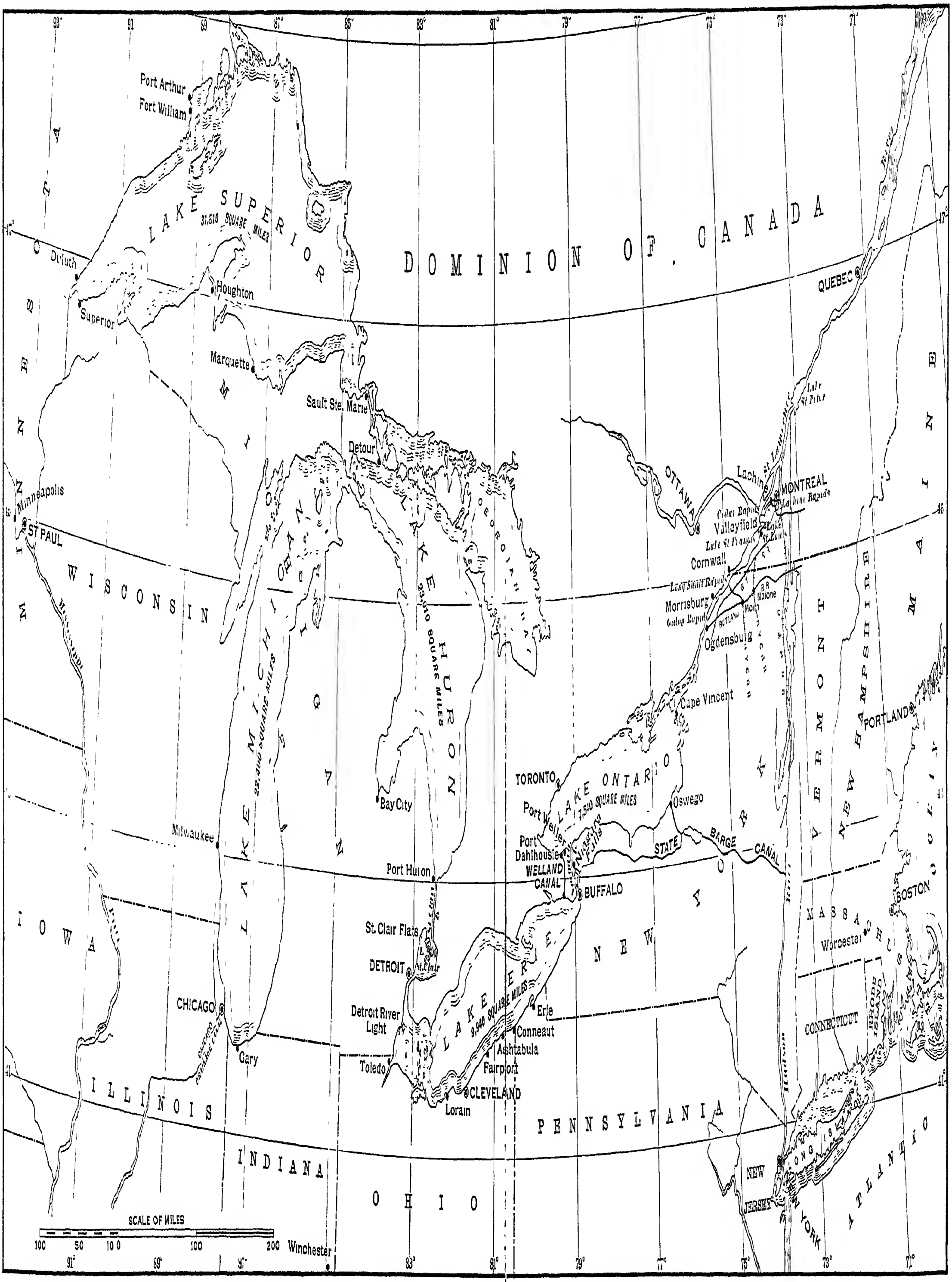


TABLE OF DISTANCES

	Statute Miles	Nautical Miles
Buffalo to Detroit	261	227
" " Chicago . .	893	775
" " Sault Ste Marie .	592	514
" " Duluth	986	856
Detroit to Chicago . . .	633	550
" " Sault Ste. Marie .	331	287
" " Duluth	726	630

AREAS OF LAKE SURFACES AND DRAINAGE BASINS ABOVE NIAGARA RIVER

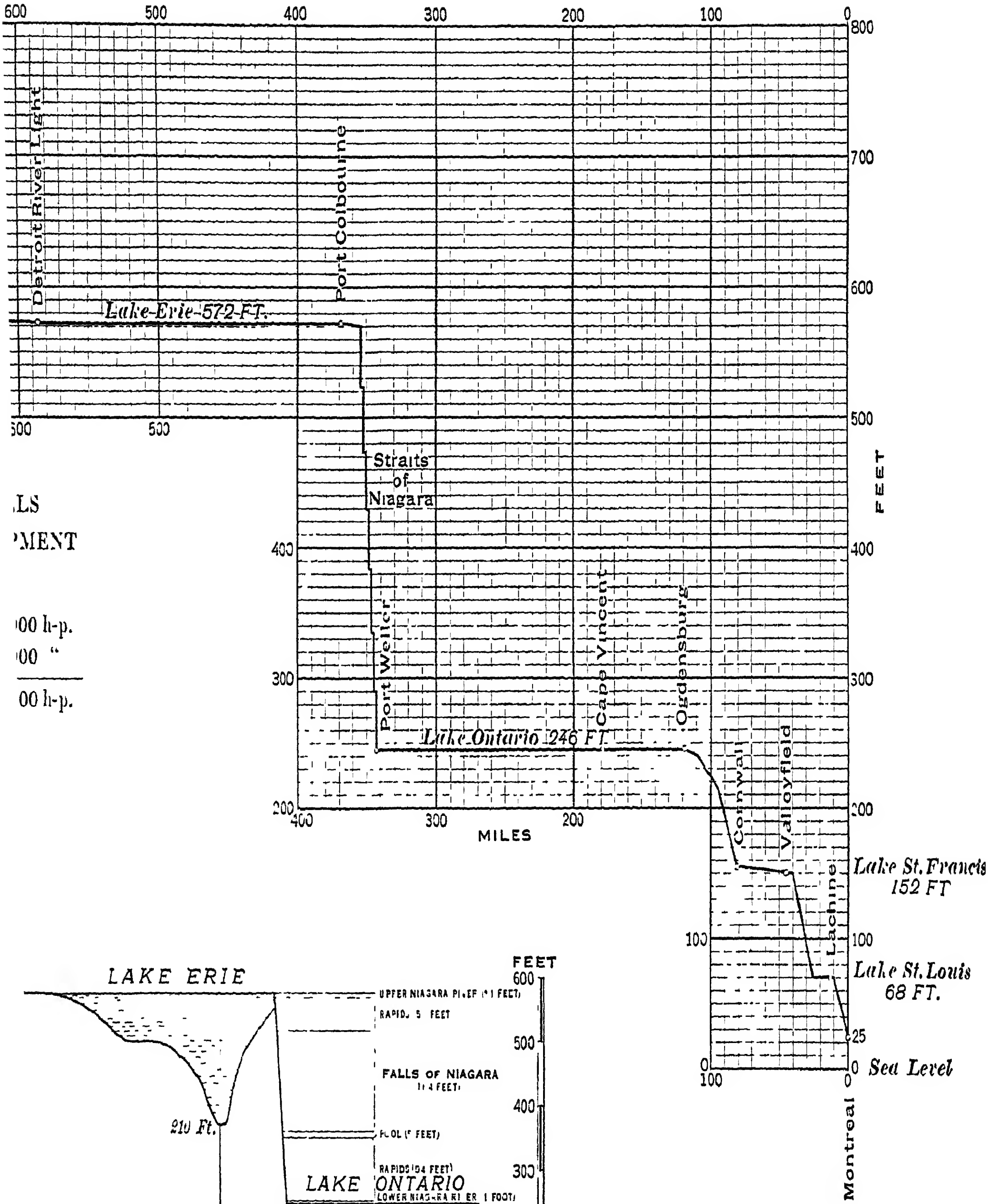
Lakes and connecting waterways	Area of lake surface in square miles	Total area of basin in square miles
Superior	31,810 (a)	80,700 (a)
Michigan	22,400	69,040
Huron	23,010 (b)	72,600 (b)
St Clair	460 (c)	6,420 (c)
Erie	9,940 (d)	34,680 (d)
Square Miles	87,620	263,440

(a) *Includes St. Mary's River above St Mary's Falls.*

(b) *Includes North Channel, Georgian Bay, and St. Mary's River below St. Mary's Falls.*

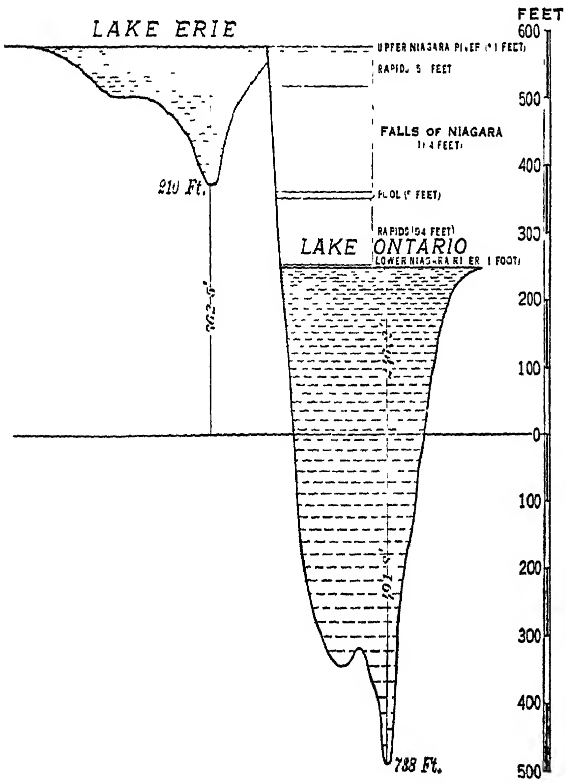
(c) *Includes St Clair River.*

(d) *Includes Detroit River.*



.LS
'MENT

'00 h-p.
'00 "
00 h-p.

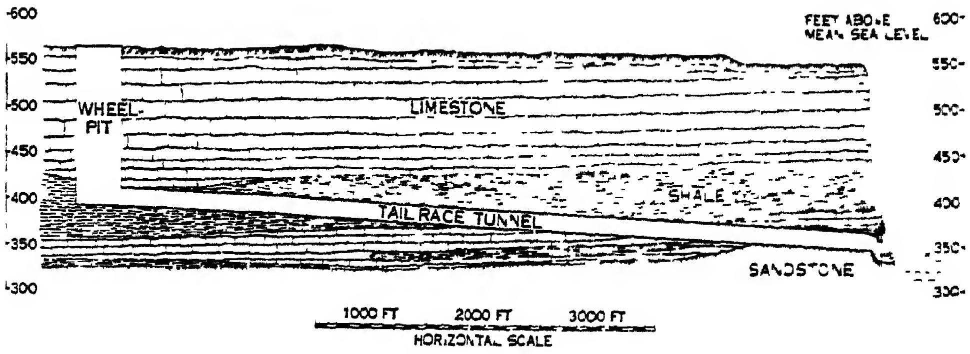


ST. LAWRENCE
ESTIMATED POWER DEVELOPMENT
1925

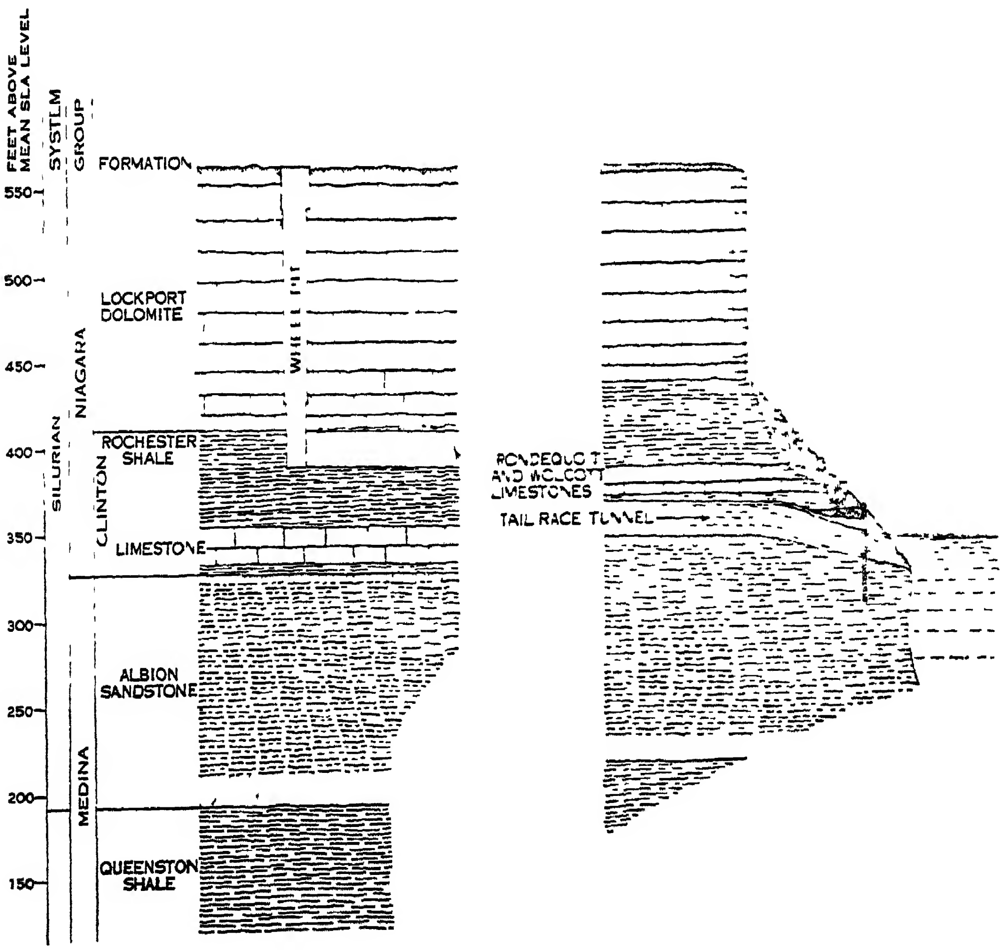
United States	87,000 h-p.	
Canada . .	218,000 "	
Total	305,000 h-p.	

POSSIBLE ULTIMATE DEVELOPMENT

About 4,000,000 *h-p.*



SECTIONAL VIEW OF WHEEL-PIT AND ORIGINAL TAIL-RACE TUNNEL SHOWING STRATIFICATION OF THE ROCKS THROUGH WHICH THE TUNNEL WAS BUILT



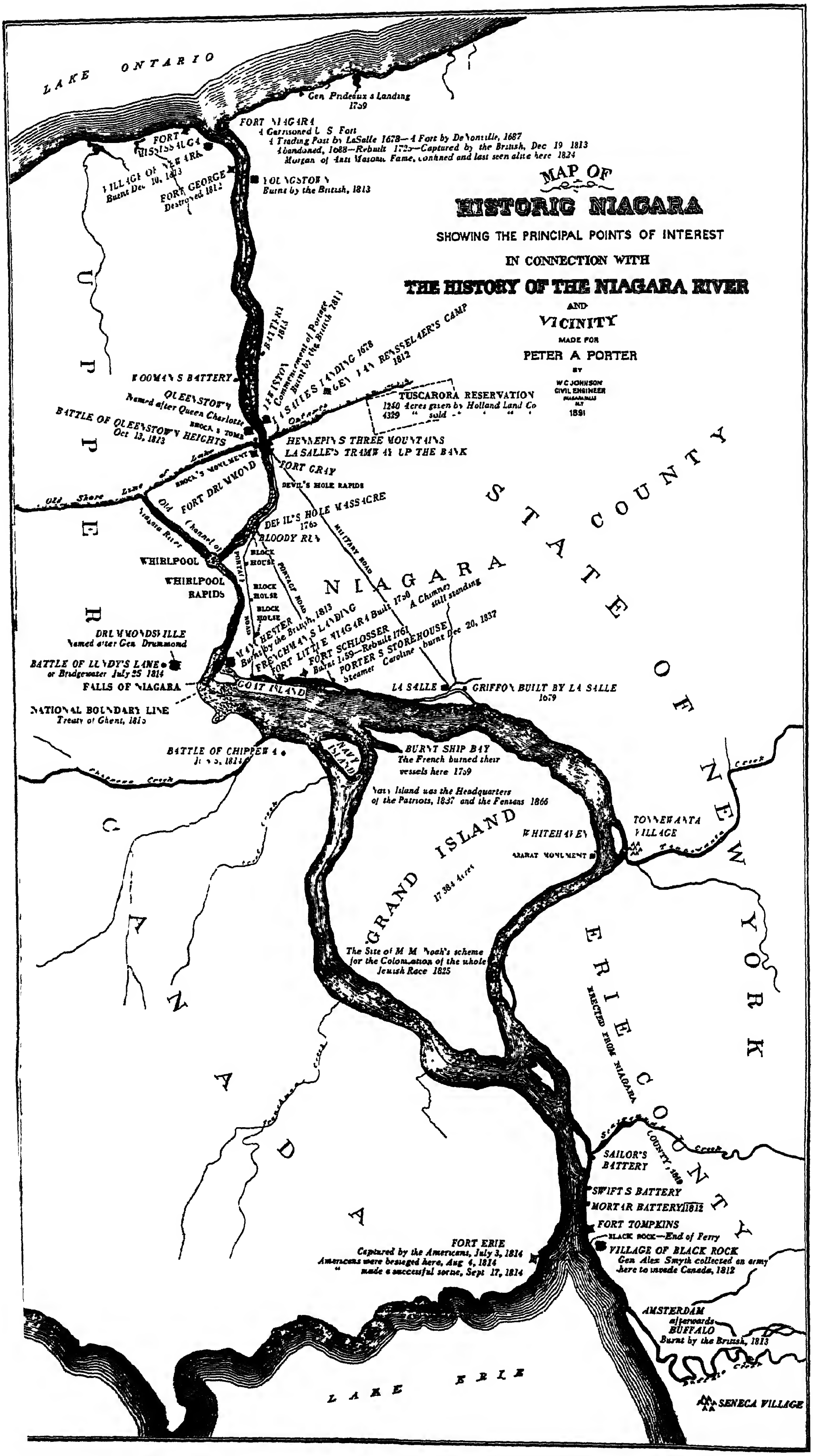
SECTIONAL VIEW OF THE STRATIFICATION AT THE WHEEL-PIT, PORTAL OF TUNNEL, AND AT THE BRINK OF THE FALLS

The great cataract is the embodiment of power. In every second, unceasingly, seven thousand tons of water leap from a cliff one hundred and sixty feet high, and the continuous blow they strike makes the earth tremble.

Niagara Falls and Their History
by G. K. GILBERT
1895

PIONEERS IN POWER DEVELOPMENT AT NIAGARA FALLS

CHAPTER II



MAP OF
HISTORIC NIAGARA
SHOWING THE PRINCIPAL POINTS OF INTEREST
IN CONNECTION WITH
THE HISTORY OF THE NIAGARA RIVER
AND
VICINITY
MADE FOR
PETER A PORTER
BY
W C JOHNSON
CIVIL ENGINEER
1891
LAKE ONTARIO
Gen Prideaux s Landing 1759
FORT NIAGARA
A Garrisoned U S Fort
A Trading Post by LaSalle 1678—A Fort by DeNonville, 1687
Abandoned, 1688—Rebuilt 1725—Captured by the British, Dec 19 1813
Morgan of Anti Masonic Fame, confined and last seen alive here 1824
FORT MISSISSAUGA
VILLAGE OF NEWARK
Burnt Dec 10, 1813
FORT GEORGE
Destroyed 1812
YOUNGSTOWN
Burnt by the British, 1813
BATTERY 1813
Commencement of Portage
Burnt by the British 1813
LEWISTON
LA SALLES LANDING 1678
GEN VAN RENSSELAER'S CAMP 1812
TUSCARORA RESERVATION
1240 Acres given by Holland Land Co
4329 " sold
ROOMAN S BATTERY
QUEENSTOWN
Named after Queen Charlotte
BROCK S TOMB
BATTLE OF QUEENSTOWN HEIGHTS
Oct 13, 1812
HENNEPIN S THREE MOUNTAINS
LA SALLE'S TRAMP UP THE BANK
FORT GRAY
DEVIL'S HOLE RAPIDS
BROCK'S MONUMENT
Old Shore Line of Lake
FORT DRUMMOND
Old Channel of Niagara River
DEVIL'S HOLE MASSACRE 1763
BLOODY RUN
MILITARY ROAD
BLOCK HOUSE
PORTAGE ROAD
WHIRLPOOL
WHIRLPOOL RAPIDS
UPPER
NIAGARA
STATE OF NEW YORK
COUNTY
DRUMMONDSVILLE
Named after Gen Drummond
MANCHESTER
Burnt by the British, 1813
FRENCHMAN S LANDING
FORT LITTLE NIAGARA Built 1750
A Chimney still standing
FORT SCHLOSSER
Burnt 1759—Rebuilt 1761
PORTER S STOREHOUSE
Steamer Caroline burnt Dec 20, 1837
BATTLE OF LUNDY'S LANE
or Bridgewater July 25 1814
FALLS OF NIAGARA
GOAT ISLAND
LA SALLE
GRIFFON BUILT BY LA SALLE 1679
NATIONAL BOUNDARY LINE
Treaty of Ghent, 1815
BATTLE OF CHIPPEWA
July 5, 1814
Chippewa Creek
NAVY ISLAND
BURNT SHIP BAY
The French burned their vessels here 1759
Navy Island was the Headquarters of the Patriots, 1837 and the Fenians 1866
GRAND ISLAND
17 384 Acres
WHITEHAVEN
TONAWANDA VILLAGE
Tonawanda Creek
ARARAT MONUMENT
The Site of M M Noah's scheme for the Colonization of the whole Jewish Race 1825
CANADA
ERIE COUNTY
ERECTED FROM NIAGARA COUNTY, 1821
YORK
Creek
SAILOR'S BATTERY
SWIFT S BATTERY
MORTAR BATTERY 1812
FORT TOMPKINS
BLACK ROCK—End of Ferry
VILLAGE OF BLACK ROCK
Gen Alex Smyth collected an army here to invade Canada, 1812
FORT ERIE
Captured by the Americans, July 3, 1814
Americans were besieged here, Aug 4, 1814
" made a successful sortie, Sept 17, 1814
AMSTERDAM
afterwards BUFFALO
Burnt by the British, 1813
Buffalo Creek
LAKE ERIE
SENECA VILLAGE

PIONEERS IN POWER DEVELOPMENT AT NIAGARA FALLS

CHAPTER II

POWER FROM THE UPPER RAPIDS

THE first use of the power of Niagara River at the falls is believed to have been made about 1757–1758 by a Frenchman, Chabert Joncaire, Jr.,[1] who built a short and narrow loop canal on the river bank a short distance above the falls. Power was probably developed by a wooden overshot wheel under a head of about 6 feet, to cut logs on what was the end of Mill Street and is now known as First Street, on the present state reservation, opposite the upper end of Goat Island.

This sawmill was repaired and used by John Steadman, who, about 1760, settled on the bank of the river near the falls on a large tract of land he claimed and received under an Indian grant. Steadman also occupied and cleared some portion of Goat Island and stocked it with goats, thus giving the island its name. He was the British master of the Niagara portage during most of the latter half of the eighteenth century. But little was done during this period to change the wild aspect of the country.

In 1795 there first comes into this history the name of the Porter family, a name that has been closely linked with Niagara development through all the succeeding generations.

Augustus Porter visited the falls in that year, and again in 1796, on his way with a company of surveyors to explore and survey the "Western Reserve," in what is now the State of Ohio. It was probably due to the favorable impressions which he received on those visits, that his family became interested in the development of Niagara and acquired important holdings of real estate including land near the falls.

It will be noted later, in further detail, that the Porters not only became large land-owners, but became identified with Niagara development in connection with transportation between the lakes.

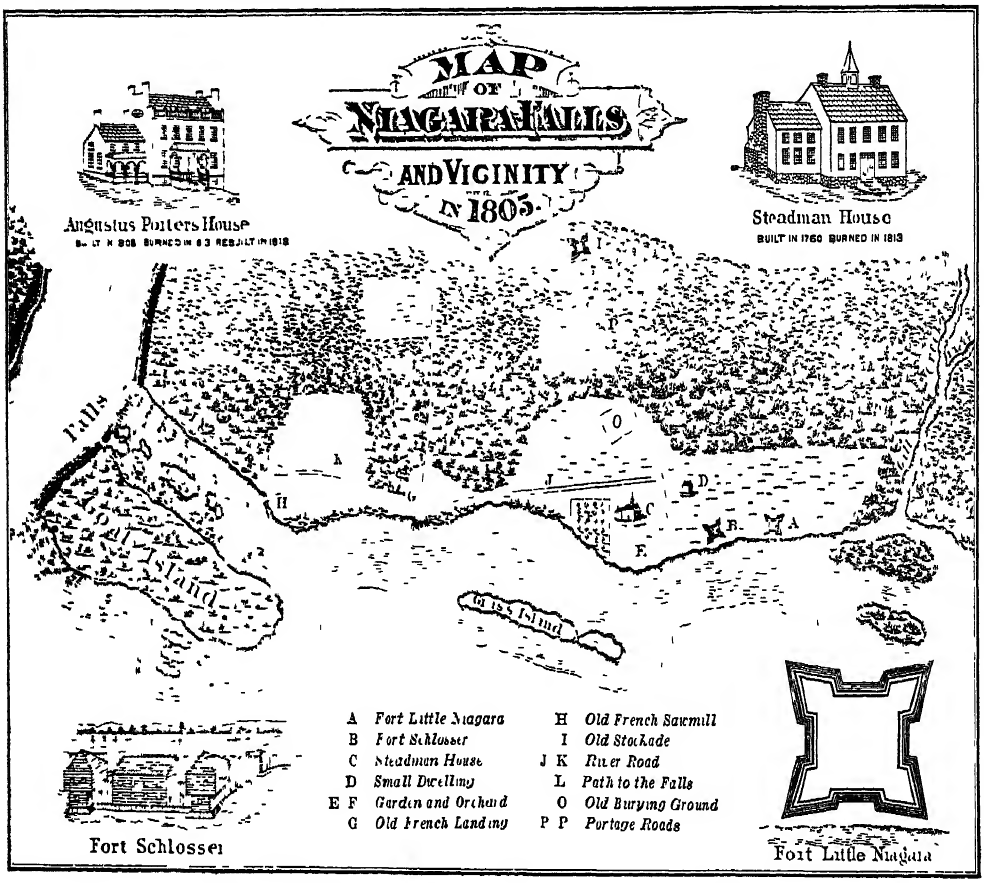
Early in 1805, Augustus Porter built a sawmill and blacksmith's shop, preparatory to other improvements. In 1806, he removed his family from Canandaigua, New York, to the old Steadman house, near Fort Schlosser. The next year he built a grist-mill, the first to be established on the American shore at the falls, with two "run of stone,"[2] on the site of the original French sawmill, using therefor a separate intake that is indicated upon a map of Niagara Falls village and river made and published by Joseph Wentworth Ingraham, of Boston, in 1836, and shown on page 43.

[1] Described by historian Peter A. Porter, as "Soldier of France, Master of the Niagara Portage and Dictator of the French Government's trade with the West."

[2] Appendix H, Volume II.

In 1809 he erected a rope-walk and a tannery, and other industries soon followed, with dwelling houses.

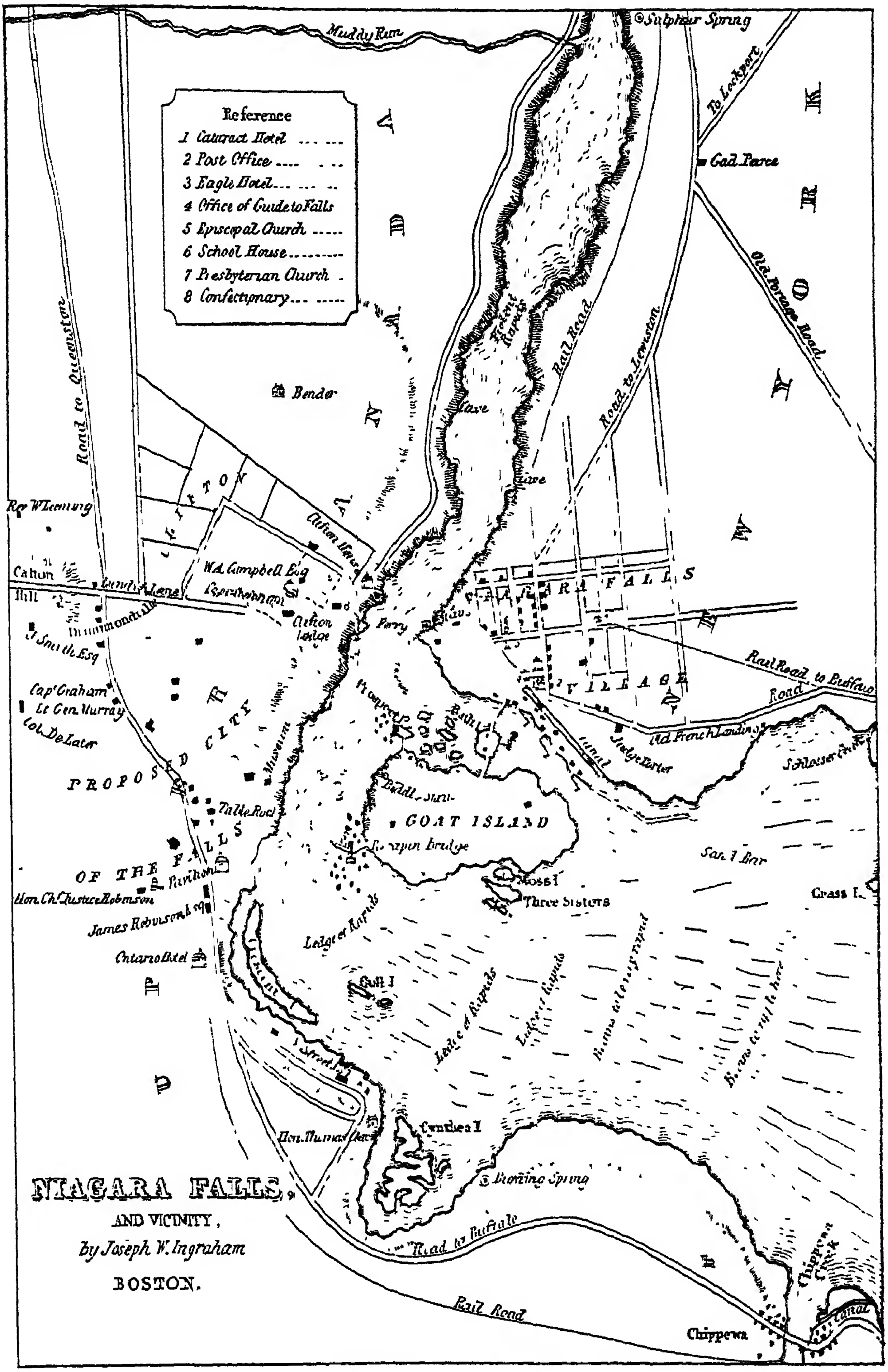
These were the beginnings of industrial Niagara. By 1812, it is stated, most of the large forest trees north of Bridge Street had been cut down, but young trees and undergrowth, particularly near the river, were very thick and close, quite down to the falls.



Map of Niagara Falls and Vicinity in 1805

LAND PURCHASES AND IMPROVEMENTS

It was not until June 27, 1814, that Augustus Porter and his partner, Benjamin Barton, finally secured from the commissioners of the land office of the State of New York, the patents of two of the lots purchased by them in 1805 at the auction sale of the "Mile Strip," particularly described in Chapter III. These were lots 42 (19 acres) and 43 (100 acres) at the apex of the angle formed by the river at the falls, bordering the upper rapids and extending to the very brink of the great cataract. In his field notes the Surveyor-General of the state had marked these two lots as "very valuable for water-power."



Niagara Falls Village, New York
and Proposed City of the Falls, Ontario, Dated 1836

The People of the State of New-York, by the Grace of GOD, Free and Independent: *To all* to whom these Presents shall come, Greeting: Know Ye, That

WE have given, granted and confirmed, and by these Presents, DO give, grant and confirm unto Augustus Porter and Benjamin Barton their heirs certain pieces or parcels of land situate in the County of Niagara, and distinguished as lots number Forty two and Forty three of the unappropriated lands lying along the Easterly side of the Niagara River as the same have been surveyed, and [illegible] map of said lands filed in the office of the Secretary of this State. The said Lot number Forty two containing Sixteen acres, and number Forty three one hundred acres

Together with all and singular the rights, hereditaments and appurtenances to the same belonging or in any wise appertaining Excepting and Reserving to ourselves all gold and silver mines *To Have and to Hold* the above described and granted premises unto the said Augustus Porter & Benjamin Barton their heirs and assigns, as an absolute estate of inheritance for ever.

In Testimony whereof, WE have caused these our Letters to be made Patent, and the Great Seal of our said State to be hereunto affixed: Witness our trusty and well-beloved Daniel D Tompkins Esquire, Governor of our said State, General and Commander in Chief of all the Militia, and Admiral of the Navy of the same, at our City of Albany, the Twentieth day of June in the Year of our Lord One Thousand Eight Hundred and fourteen and in the Thirty-eighth Year of our Independence.

Passed the Secretary's Office, the 27th *Day of* June 1814

Archd Campbell Dep Secretary

Daniel D Tompkins

I have examined the preceding Letters Patent, and do Certify *that the same are conformable to the Orders and Proceedings of the Commissioners of the Land Office, and in due form of law.*

[illegible] 20 June

DEED FROM THE STATE OF NEW YORK TO AUGUSTUS PORTER AND BENJAMIN BARTON ON JUNE 27, 1814

According to a map from a survey by George Catlin, in 1831, the industries then located on the banks of the Niagara River, utilizing the power developed by the loop canals, enumerating from the bridge to and over Bath Island to Goat Island are as follows: at the right hand side of the bridge across the river, Trip Hammer Nail Factory; on the left or easterly side, a paper-mill and a grist-mill; at some distance, a second grist-mill followed closely by a woolen factory, and, slightly beyond, a sawmill, not far from the residence of Judge Porter.

On November 19, 1816, Augustus Porter made a further notable acquisition of Niagara property by securing from the State of New York the patent[1] of

> a certain Island commonly called and known by the name of Goat Island, situate and lying in the rapids of the Niagara river immediately above and adjoining the Great Falls, the northwesterly side of which Island terminates with the perpendicular rock of precipice forming the Falls, together with several small Islands or masses of rocks surrounding and appendant to the said principal island but separated from the same by small sheets of water containing in the whole according to a plan and survey of the same made by Parkhurst Whitney on the 10th day of October, 1815, and now on file in the Secretary's office, about sixty-two acres.

It is interesting to note that the deeds conveying the ownership of these lands and island were executed by

> our trusty and well beloved Daniel D Tompkins, Esquire, Governor of our said State, General and Commander in Chief of all the Militia, and Admiral of the Navy of the same, at our City of Albany

In both deeds

> the people of the State of New York, by the grace of God Free and Independent, make the grant of land excepting and reserving to ourselves all Gold and Silver Mines

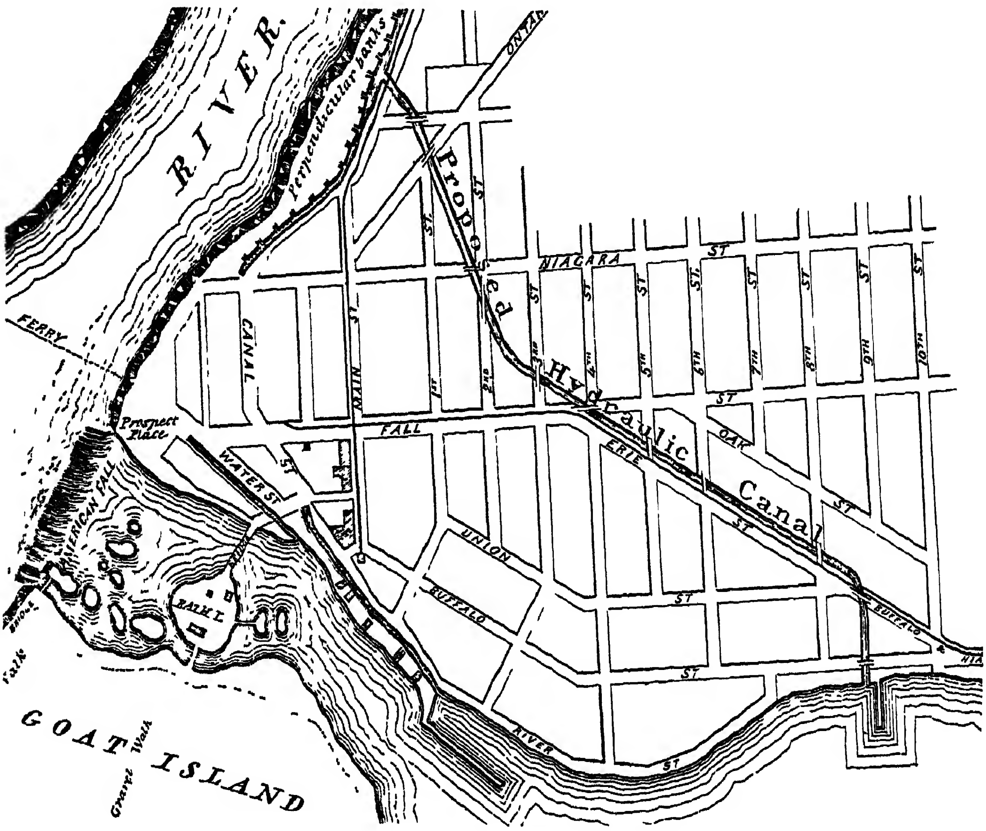
From a point near the head of the island, Augustus Porter constructed a bridge to the mainland. This bridge proved insufficient to resist the strong current and heavy masses of ice at that point, and it was partially carried away the first winter and spring. Within a year another bridge was constructed across the rapids below, on the site of the present bridge, which has proved to be a perfectly secure position. For the old bridge of wood a bridge of iron was substituted in 1856, and this was replaced in 1900 by a multiple-arch bridge of concrete with stone facing.

In 1822, Augustus Porter erected the large flouring-mill subsequently owned by Witmer Brothers, and the next year a paper-mill was built by Jesse Symonds, near Goat Island bridge.

[1] A fee of $1.38 for acknowledging and recording this patent is recorded in the memorandum cash book of A. Porter.

In 1826, the upper raceway or canal was extended, and on the extensions, Ira Cook, William G. Tuttle, Capin & Swallow, and others, erected works of different kinds. A large paper-mill was built on Bath Island by Porter & Clark, which was greatly extended by L. C. Woodruff.

What has been called the "upper raceway" upon the earlier maps of the village of Niagara Falls, is supposed to have been built in 1820, when



Niagara Falls Village

Showing Proposed Hydraulic Canal

Submitted by P Emslie, December, 1846

the Porter Brothers erected a grist-mill. This canal did not extend towards the falls nearer than the street leading to the Goat Island bridge. Another small canal designated as the "lower raceway" was constructed about 1845 and it is said that a paper-mill, a woolen factory and a nail-mill were built thereon close to Goat Island bridge. Both raceways were in use in 1884 and were purchased with all structures thereon by the State in 1885 as a part of the New York State Reservation at Niagara Falls.

RETARDED DEVELOPMENT AND NEW PLANS

A serious interruption to the progress of settlement and improvement at Niagara, and in all the surrounding country, was occasioned by the War of 1812, which subjected the people to great sacrifices and suffering.

Before[1] the village had recovered from the effects of the war, and while the surrounding country, suffering from that and other embarrassments, was making very slow progress in improvement, at the early period of 1825, the Erie Canal was opened to its full extent.

The immediate effect was to divert all the business of transportation from the old channel, and to attract all enterprises and capital seeking employment to the numerous villages growing up on the line of the canal. Another injurious effect of the canal on this locality, though beneficial to the new villages, was the very large and widely extended water-power it afforded, at points where little or none had previously existed, at Black Rock, Lockport, and other towns west of Rochester, adding greatly to their growth and proportionally lessening ours.

General Marquis de Lafayette visited Niagara Falls in 1825. In the account[2] of this visit, his secretary, M. La Vasseur, wrote respecting Goat Island:

The surrounding currents of water offer an incalculable moving power for machinery, which might be easily applied to all sorts of manufactories.

INVITATIONS TO DEVELOP NIAGARA POWER

In 1825, Augustus Porter and Peter B. Porter issued, as "proprietors of the lands which embrace the Rapids and Falls, on the American side of the Niagara; also of Iris (Goat), Bath, and the other small islands lying in the rapids and connected by bridges with the main shore," an "Invitation to Eastern Capitalists and Manufacturers" to develop the power at Niagara Falls, offering to become interested in any such company to the extent of their means. This appears to have been the first public effort to secure capital for the utilization of Niagara power by the location of manufactories and a town at the falls. The "Invitation"[3] states that

the inadequacy of capital in this part of the country to undertakings of this kind, added to the doubts which have until very recently existed in regard to the success of American manufactures generally, has hitherto prevented the improvements which this situation so powerfully invites.

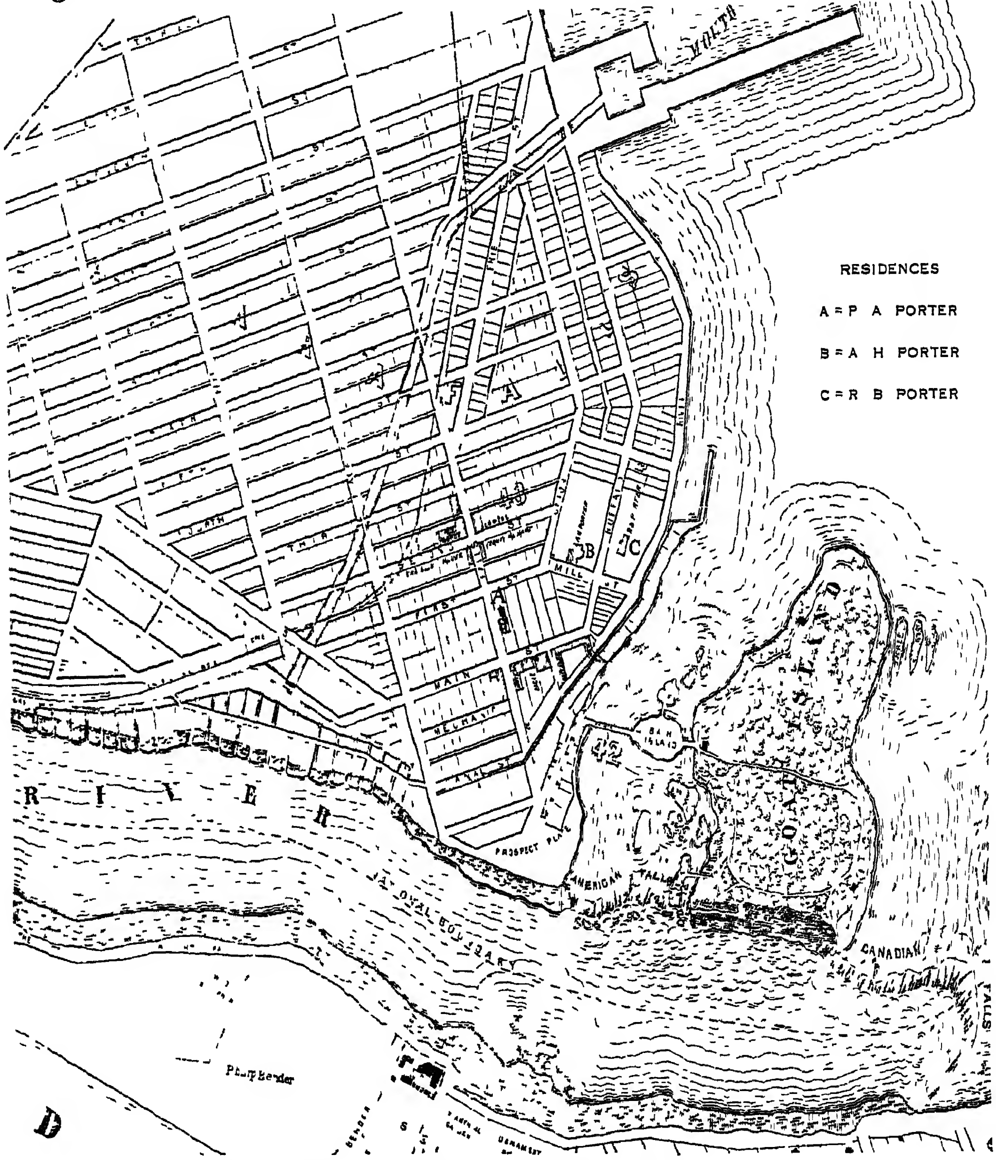
It appears from the terms of this "Invitation," that the Porters were planning to utilize, not the great cataract itself, but only the 60 feet of the upper rapids, in the three-fourths of a mile of their descent before the river reaches the falls.

[1] *Niagara, Past and Present*, Albert H. Porter, 1876.

[2] *Lafayette en Amerique 1824 et 1825*, 2 vols., Paris, 1829.

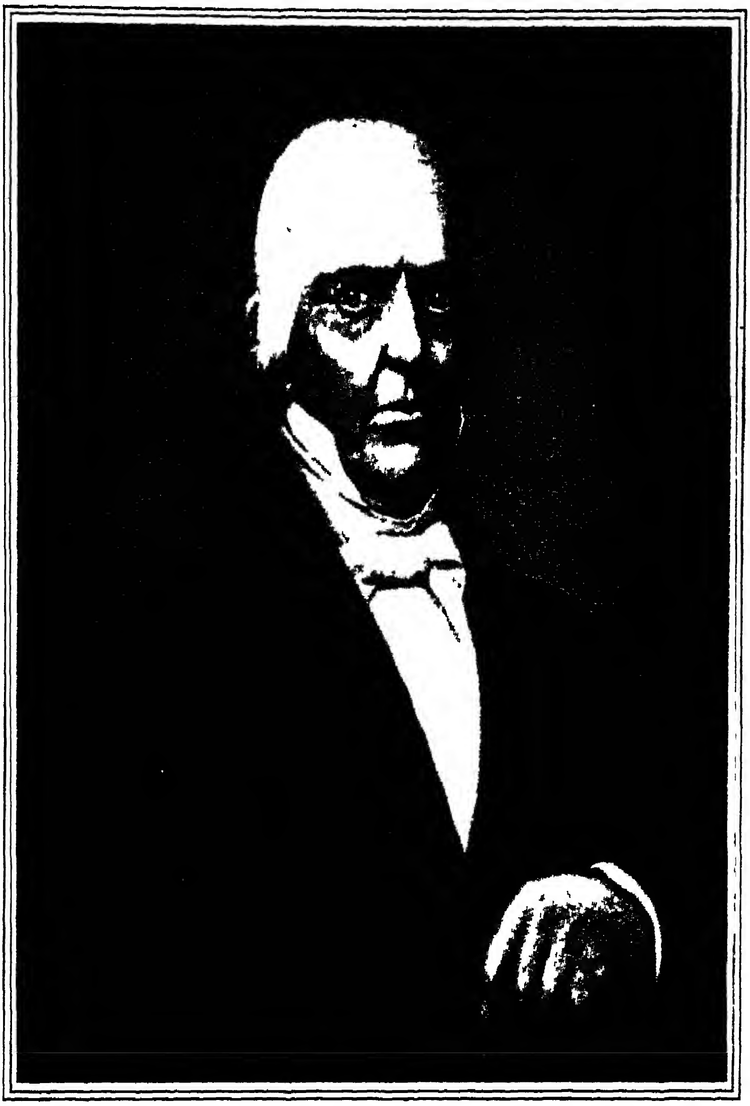
[3] Appendix C, Volume I.

The "Invitation" of 1825 does not appear to have been successful in securing the co-operation of the necessary capitalists nor did the next two decades witness any material progress in the utilization of the power of Niagara.



FROM A MAP OF THE VILLAGES OF NIAGARA FALLS AND NIAGARA CITY, DATED 1856

A Buffalo publication of 1835 refers to a paper-mill, a flouring-mill, and a few mechanics' shops as constituting the industrial activity of the village of Niagara Falls, while two spacious hotels, the Eagle and the Cataract, afforded accommodations for one hundred permanent guests. A map was issued in 1846 showing a projected extension of the upper raceway through



AUGUSTUS PORTER

1769–1849

PIONEER SURVEYOR, 1789

POWER PIONEER OF NIAGARA, 1806

FIRST JUDGE OF NIAGARA COUNTY, 1808

Canal Street, now Riverway, of the New York State Reservation, and down the river bank to and beyond the present Pine Street.

In 1845 the inclined plane at the ferry, with cars operated by water-power, was substituted for the old plan of winding stairs to the river.

HYDRAULIC CANAL

During this long period of stagnation, the Porters did not lose faith in Niagara. Failing to interest manufacturers in their plan for the utilization of the 60-foot fall of the rapids above the great cataract, they gave support to a new plan which has resulted in a development far beyond their hopes or vision.

The new project included the construction of a harbor, with wharf, opposite Grass Island, near the end of river navigation, and a canal, not for inter-lake transportation, but a "hydraulic canal," or large raceway, that would conduct a large volume of water across the point of land enclosed within the right angle of the turn of the river, to a "reservoir" or canal basin, to be located on the bluff above the river bank about one-half mile below the falls, where power would be available from the fall of water from the bank, about 200 feet, to the river below.

Without doubt, Judge Augustus Porter, who owned the lands through which this canal passed, early saw the importance of its construction and for several years before his death in 1849, made the most liberal offers to capitalists to engage in the undertaking, as the expense involved exceeded his own means. The interesting account of the development and outcome of this project is reserved for Chapter IV, entitled "The Hydraulic Canal."

PORTER BROTHERS, PIONEERS

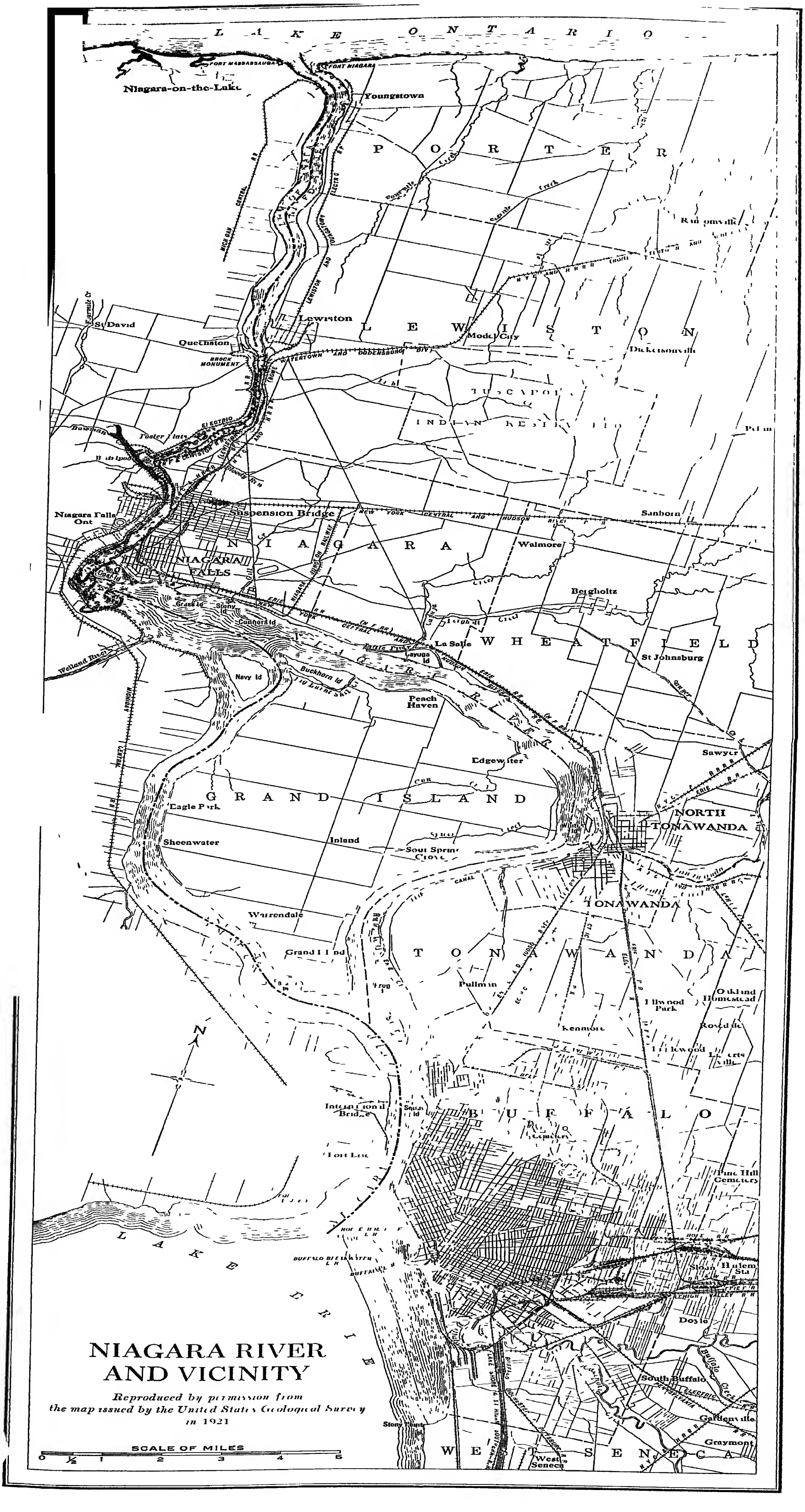
The Porter Brothers were the power pioneers of Niagara. Their large purchases of land on the river bank were an evidence of their vision and courage. By reason of their activities between the years 1800 and 1850, they were recognized at that period as the most influential and public-spirited citizens of their community. They firmly believed in the future of Niagara as a manufacturing district, and were diligent in making known the water-power potentialities of Niagara Falls. By maintaining portage transportation[1] around the falls from Lake Erie to Lake Ontario, and by establishing industries at the village, they promoted the settlement and development of that section of the country. To assist the formation of power companies, they contributed of their lands and water-rights as a means of obtaining capital from sources outside of their districts for the development and use of Niagara power. As is generally the case with pioneers in great industries, they did not live to see the accomplishment of the undertaking in which their fortune, courage and enterprise were so fully enlisted.

[1] Described more fully in Chapter III.

THE "MILE STRIP" AND THE PORTAGE LEASE

1803–1805

Chapter III



NIAGARA RIVER AND VICINITY

Reproduced by permission from the map issued by the United States Geological Survey in 1921

SCALE OF MILES

0 ½ 1 2 3 4 5

THE "MILE STRIP" AND THE PORTAGE LEASE

CHAPTER III

HISTORY OF LAND TITLES

THE right to use water in power production is so closely related to land ownership that the unique history of land titles at Niagara is an important factor in the history of Niagara power.

The purchase from the state of lands on the river-side was made in confident expectation of acquiring thereby the ownership of the adjoining land under water and riparian rights to its use, a most important title in establishing the hydraulic canal upon the real estate donated by the Porter family to promote this great enterprise.

The purchase of property to be held as the state reservation clouded this water-right and was only cleared after an appeal to the State Constitutional Convention and the legislature, the latter ratifying the title, as will be explained in Chapter XI.

By the Treaty of Paris, 1783, terminating the Revolutionary War between the United States and Great Britain, the State of New York became the owner of a strip of land 1 mile wide on the eastern bank of Niagara River, extending southerly along the river front for about 16 miles, from Lake Ontario. This land was part of the tract, 4 miles wide on each side of Niagara River, from Fort Niagara to Fort Schlosser, that England had exacted from the Seneca Nation in 1764 by the treaty which Sir William Johnson made with these Indians, as part indemnity for the massacre of English troops and settlers at "Devil's Hole" on Niagara River, on September 14, 1763

In a settlement of conflicting claims between the State of New York and the Commonwealth of Massachusetts, by deed of mutual cession dated December 16, 1786, the State of New York reserved from its cession to Massachusetts its title to this land, which became known as the "Mile Strip," and was described in the agreement as follows:

> Westerly and southerly along said (International) boundary line (in Lake Ontario) to a meridian which will pass one mile due east from the northern termination of the Streight (as spelled in the treaty) or waters between Lake Ontario and Lake Erie; thence south along the said meridian to the south shore of Lake Ontario; thence on the easterly side of the said Streight, by a line always one mile distant and parallel to the said Streight, to Lake Erie.

In 1802, the State of New York acquired by treaty with the Seneca Indians their title to 20 miles of the lands included in the "Mile Strip" on the eastern bank of Niagara River, thus completing the state's ownership of all the land of the "Mile Strip" from Lake Erie to Lake Ontario, about 36 miles.

The New York Legislature, in 1798, directed the Surveyor-General to survey the "Mile Strip"; to lay out the land in lots, and to provide for a town site. About the year 1800, a town site 1 mile square was located opposite Queenstown, and on February 25, 1805, it was named Lewiston by the commissioners of the land office of the state, in honor of Governor Morgan Lewis of the State of New York.

SALE OF STATE LANDS

On April 6, 1803, the legislature passed an act directing that all unappropriated lands of the state be sold, and removed the inhibition established by the Act of May 11, 1784, against the grant, by the state as bounty, of the lands constituting the "Mile Strip."

The commissioners of the land office authorized the Surveyor-General to advertise and sell all the lots in the village (Lewiston) laid out on the Niagara River, opposite Queenstown, located between certain streets, but at not less than five dollars per lot.

PURCHASERS OF LOTS

A map of the survey made in 1805 by Joseph Annin, deputy surveyor, under the direction of Simeon de Witt, surveyor-general, was prepared showing the division of the "Mile Strip" into lots, which were offered for sale at auction, February 26, 1805. This map is reproduced here, with the official record of sales of lots contiguous to the falls.

PORTAGE LEASE

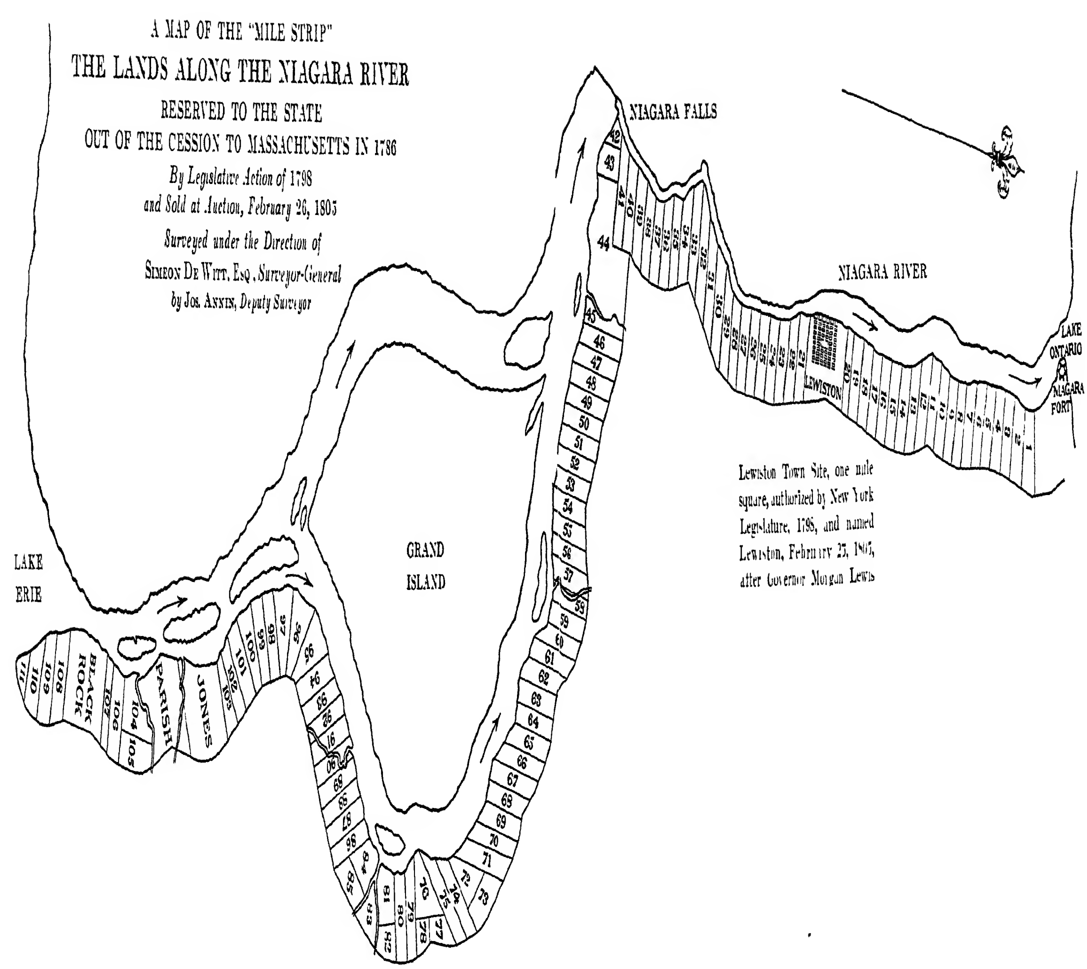
The Act of 1803, also authorized the lease of the Niagara portage, between Lewiston, on the lower river near Lake Ontario and Fort Schlosser on the upper river, together with the necessary land at each end thereof. The commissioners of the land office, on December 17, 1804, announced that proposals for such a lease would be received until March 12, 1805

Joseph Annin and Benjamin Barton (signing Jos Annin and Ben Barton) filed their proposal "for leasing the carrying and landing places on Niagara River and the Ferry at Queenstown." They offered to erect the stores and wharves, and to make the other improvements required on the part of the state for a lease of the premises and privileges for the term of twelve years.

The commissioners of the land office in meeting

> proceeded to open the several proposals made for leasing the old Carrying and Landing places on the Niagara River with the ferry opposite to Queenstown; and it appearing to the satisfaction of the Board that the proposals offered by Joseph Annin and Benjamin Barton were most advantageous to the interests of the State; and they having offered Peter B. Porter as their security: Thereupon
>
> Resolved, that their proposals be accepted, and their said security approved, and that the Secretary prepare Leases conformable to their said proposals and to the act

A Map of the "Mile Strip" Lands Along the Niagara River



SALES OF THE LANDS ALONG THE NIAGARA RIVER, MADE ON FEBRUARY 26 1805

No Lot	Purchasers	No Acres	Price Per Acre
1	Barent Sanders	183	$ 3 60
2	Barent Sanders	187	3 60
3	Joseph Annin	158	3 60
4	Alexander Miller	155	3 60
5	John McBride .	154	3 60
6	Walter Stewart .	158	3 60
7	Alexander Watson	165	3 60
8	John McBride	150	3 15
9	John McBride .	142	3 15
10	Hugh R Martin for Nath'l Buell	155	2 70
11	Arch'd McIntyre & John McDonald	174	3 37½
12	Alexander Miller	167	3 60
13	Joseph Annin .	169	3 60
14	Joseph Annin . .	162	4 50
15	Joseph Annin	160	4 05
16	Alexander Miller . . .	160	4 05
17	Alexander Miller	160	4 05
18	Benjamin Barton	160	4 05
19	Benjamin Barton . . .	160	4 05
20	Benjamin Barton . . .	108	4 05
21	Arch'd McIntyre & John McDonald	159	4 27½
22	Arch'd McIntyre & John McDonald	154	4 27½
23	Benjamin Barton	154	4 05
24	John Carpenter	154	3 60
25	Isaac Colt	151	3 60
26	Alexander Miller	144	3 60
27	Benjamin Barton	145	3 37½
28	Arch'd McIntyre & John McDonald	148	3 37½
29	Benjamin Barton	156	3 15
30	Joseph Alvord	204	3 15
31	Daniel Steele	204	3 15
32	Archd McIntyre & John McDonald	212	292½
33	Jacob Mancius	197	2 70
34	William Low	166	292½
35	William Low .	159	292½
36	Peter B Porter	156	337½
37	Peter B Porter for Leonard Stevens	153	337½
38	Peter B Porter for August Porter	161	337½
39	Peter B Porter for August Porter	168	337½
40	Joseph Annin . . .	172	3 60
41	Joseph Annin	182	3 60
42	Peter B Porter & Benjamin Barton	19	18.00
43	Peter B Porter & Benjamin Barton	100	13.50
44	Stedman Farm . . .	681	*
45	John Osborn & Jared R Tyler .	150	1.80
46	Isaac Colt	160	1.80
47	John Osborn & Jared R Tyler .	166	1.80
48	John Osborn & Jared R Tyler .	169	1.80
49	John Osborn & Jared R. Tyler .	164	1.80
50	Jacob Gilbert	160	2 25
51	Jacob Gilbert	161	2 25
52	James Emott	161	1 80
53	James Emott	162	1 80
54	David Rogers	160	1.80
55	Benjamin Barton	161	1 80
56	Jacob Gilbert	164	1 80
57	Jacob Gilbert	166	1 80
58	Jacob Gilbert	162	2.25
59	Jacob Gilbert	168	2.25
60	Jacob Gilbert	192	2.25
61	Jacob Gilbert .	176	1 80
62	Jacob Gilbert	162	1 80
63	David Rogers	165	1 80
64	John McDonald & Archd McIntyre	163	1 80
65	Jacob Gilbert	172	1.80
66	Daniel Mallon	194	2.25
67	Daniel Mallon	194	2 25
68	William Ernott	172	2 25
69	Daniel Mallon	175	2 25
70	Levi H Palmer . .	196	2 25
71	Levi H Palmer	213	2 25
72	William Stevens . .	113	1 80
73	Beriah Palmer . .	180	1 57½
74	Beriah Palmer .	210	1 57½
75	William Ernott . .	224	1 80
76	Matthew Caldwell . .	175	1 80
77	John Bird	91	90
78	Alexander Stewart	61	90
79	Matthew Caldwell . . .	175	1 80
80	Wilhelmus Mynderse . .	184	1 80
81	Arch'd McIntyre & John McDonald	173	2 25
82	Arch'd McIntyre & John McDonald	98	1 80
83	Jacob Gilbert	155	1 35
84	Arch'd McIntyre & John McDonald	224	2.25
85	Arch'd McIntyre & John McDonald	148	1.80
86	Benjamin Barton	157	2.25
87	Arch'd McIntyre & John McDonald	157	2.25
88	Arch'd McIntyre & John McDonald	157	2.25
89	Archibald Campbell	157	2.25
90	Archibald Campbell	157	2.25
91	Benjamin Barton	157	2 25
92	George Van Slyke	170	2 25
93	John Randel, Jr	170	2 25
94	John House	180	2 25
95	John Barber	219	2 25
96	John House	220	2 25
97	Joseph Annin	210	2 25
98	Constant Woodworth	162	2 25
99	Sewall Abbot	160	2 25
100	John Barber	171	2 25
101	Thomas Mumford	187	2 25
102	Benjamin Barton	160	2 25
103	Arch'd McIntyre & John McDonald	132	2 25
104	John McDonald, Arch'd McIntyre Benjamin Barber, Birdsey Norton & Peter B. Porter . .	232	4 05
105	John McDonald, Arch'd McIntyre Benjamin Barber, Birdsey Norton & Peter B. Porter	168	3 15
106	John McDonald, Arch'd McIntyre Benjamin Barber, Birdsey Norton & Peter B Porter . .	208	4 05
107	John McDonald, Arch'd McIntyre Benjamin Barber, Birdsey Norton & Peter B. Porter	100	5.40
108	Included in the Village of Black Rock	194	5.00
109		205	4 50
110		192	4 00
111		90	4.00

* An Indian grant, confirmed by the state and 100 acres sold to Peter B Porter

entitled "An Act for the sale of the unappropriated Lands and for other purposes" passed the 6th of April, 1803.

The engrossed lease, in duplicate, was approved and the commissioners executed the same "on behalf of the People of this State," on March 16, 1805.

The firm of Porter, Barton & Company was formed at this time, all four partners, Augustus Porter, Peter B. Porter, Benjamin Barton and Joseph Annin being present at the bidding, award and signing of the portage lease, which was assumed by the new firm.

The land transport was by Indians, by ox-carts and by horse-wagons. The principal article of commerce was salt in barrels, received from Oswego on Lake Ontario, to be shipped westward from Buffalo.

PORTER, BARTON & COMPANY, FORWARDERS

Under the authority of the lease, which for all practical purposes was without competition, Porter, Barton & Company conducted the commerce of the portage in both directions by land and by water, having their own vessels, owned or otherwise controlled, on both Lake Erie and Lake Ontario. This firm established the first line of transportation between New York and Buffalo, Cleveland, and Pittsburgh, which were distributing points. They, in effect, issued through bills of lading, and made through rates, being assisted in this business by their agents at Oswego, Messrs Walton & Company.

Porter, Barton & Company received freight from New York at Oswego, on Lake Ontario, where it was loaded on their vessels and carried to Lewiston. There the freight was transferred to the ox or horse teams and carried over the portage to Fort Schlosser, about two miles above the Great Falls. It was there placed aboard their own *Durham* boats, that were poled by Indians or others up Niagara River to Black Rock, where the freight was stored in the warehouses built opposite Squaw Island,[2] for shipment in their own vessels on Lake Erie to its western destinations. The salt shipments westward amounted to from fifteen thousand to eighteen thousand barrels annually. It is stated that five thousand barrels of salt were at one time at Black Rock awaiting vessels to load it for transport west, primarily to Cleveland.

The charges for transportation, storage and ferriage were quoted as follows:

Seven shillings per barrel, Lewiston to Black Rock
Three shillings per barrel, Schlosser to Black Rock

[1] A fleet of five boats, each carrying 150 barrels of salt.

[2] Originally known as Scoy-gu-quides Island, near the entrance to the Erie Canal. A gift from the Seneca Indians to their trusted interpreter, Captain Jasper Parish, who, under the authority of a confirmatory act of the state legislature in 1816, sold the island in 1823 to Henry F. Penfield

Six shillings per cwt. and upward for other freight, Lewiston to Black Rock
For storage twelve cents per barrel
For transportation across the carrying place at the rate of twenty-five cents for every cwt.

An ox-team hauled twelve barrels, and a two-horse wagon carried seven barrels of salt.

Ferriage at Queenstown as follows:

	Rate in Cents
Man and horse	25
One horse	12½
One foot passenger	6
Wagon and two horses	75
Additional horse	10
Cart and oxen	75
Cattle per head	12½
Sheep and hogs	3
Sleigh and horse	75

The War of 1812 seriously interfered with the transportation operations of this firm. The lease of the portage acquired by the firm of Porter, Barton & Company expired by its terms at the end of twelve years, on March 16, 1817, and was extended for four years in recognition of the forced suspension of the business during the war.

PORTER BROTHERS AS LAND OWNERS AT NIAGARA

In 1825, the Erie Canal was opened for its entire length from Niagara River, near Squaw Island, at Black Rock (Buffalo) to the Hudson River at Albany, thus establishing an all-water route to New York City. The effect of the canal in diverting traffic from the old portage route through Niagara Falls and its paralyzing influence upon the business prospects have been recounted in the preceding chapter.

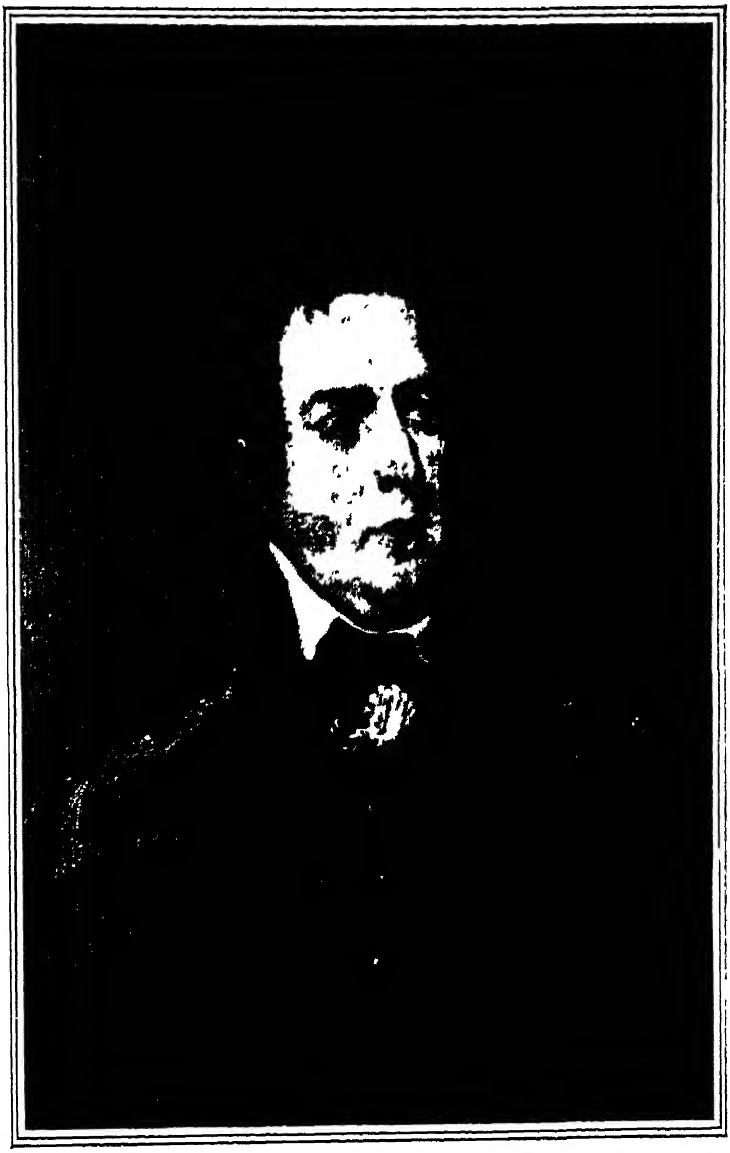
The new transportation route by canal practically terminated the pioneer business of the Porter Brothers as merchants and forwarders and as owners of a system of transportation on lakes Erie and Ontario and over the land portage around the Great Falls. In their portage business they are reported as having established

> the first regular and connected line of forwarders that ever did business from tidewater to Lake Erie on the American side of the Niagara River,

and of which it has been said it

> never wanted in efficiency or in prompt and honorable dealings.

Largely as a result of their own contribution to the westward advance of the settlement of this country, their portage transit was supplanted by the Erie Canal and, a few years later, by the growing network of railroads. They

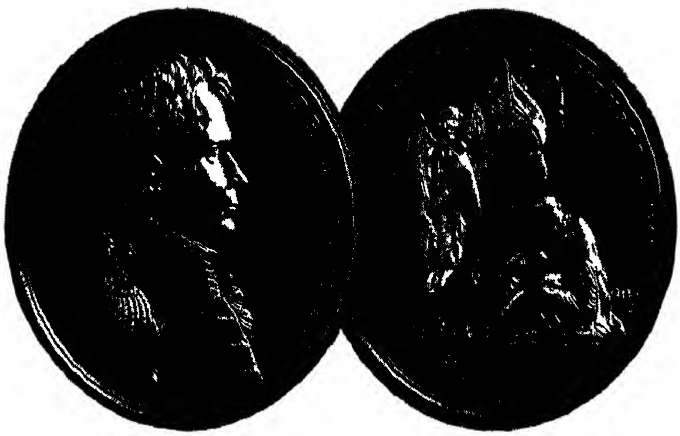


PETER BUELL PORTER
1775–1844
PIONEER BARRISTER, 1795
POWER PIONEER OF NIAGARA, 1806
LAND OWNER
GENERAL COMMANDING NATIONAL FORCE
IN WAR OF 1812
HONORED BY CONGRESS AND THE STATE
AND CITY OF NEW YORK

had become identified with the settlement of Niagara, where they were the largest owners of important tracts of real estate favorably located for power development and manufacturing purposes.

As pioneers in power development the Porter Brothers again devoted their influences and activities to the upbuilding of Niagara as a center of population and commerce. In this new period of their careers the great cataract was to be again the pivot of their public lives. Its hindrance to commerce had been the foundation of their business success; they now saw their opportunity in its vast undeveloped power, which became their hope for the utilization of their large landed estate, as well as for the community in which they dwelt.

On June 24, 1825, they issued their "Invitation[1] to Eastern Capitalists," the first of their many efforts, to which reference has already been made in Chapter II, to enlist aid in this great work.



PETER BUELL PORTER
1775–1844

By Resolution of Congress, November 3, 1814, a gold medal[2] was struck and presented to Major-General Porter in testimony of the high sense entertained by Congress of his gallantry and good conduct in the battles of 1814: at Chippewa, July 5; Niagara (Lundy's Lane), July 25; Erie, September 17.

[1] Appendix C, Volume I

[2] Stolen; bronze replica struck for General Porter.

THE HYDRAULIC CANAL

1847–1918

THE BEGINNING OF THE ENTERPRISE WHICH DEVELOPED INTO THE NIAGARA FALLS HYDRAULIC POWER AND MANUFACTURING COMPANY

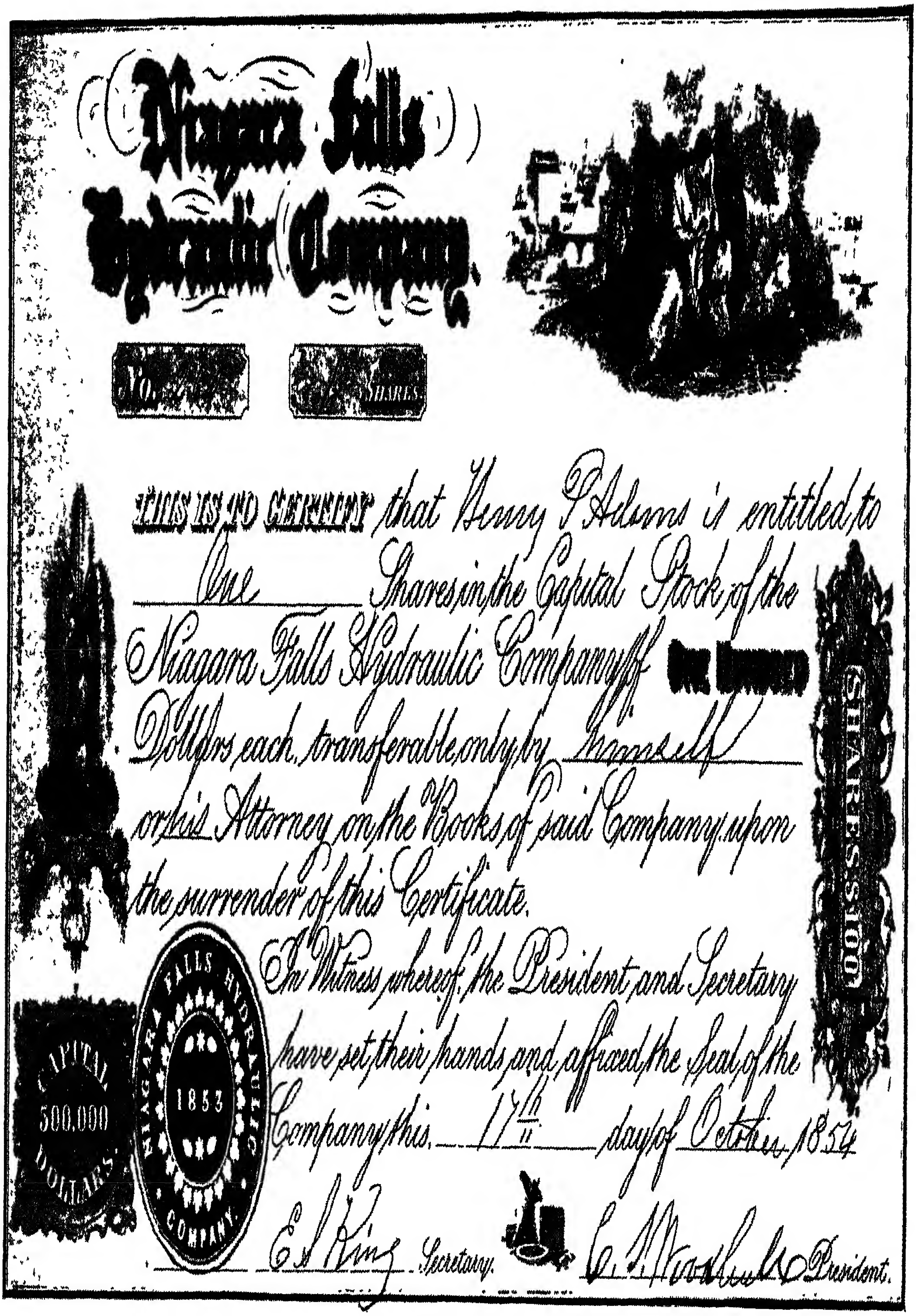
WHICH CONSOLIDATED WITH

THE NIAGARA FALLS POWER COMPANY (1886)

FORMING

THE NIAGARA FALLS POWER COMPANY MCMXVIII

Chapter IV



Niagara Falls Hydraulic Company.

No. Shares

THIS IS TO CERTIFY that Henry P. Adams is entitled to One Shares in the Capital Stock of the Niagara Falls Hydraulic Company of One Hundred Dollars each, transferable only by himself or his Attorney on the Books of said Company upon the surrender of this Certificate.

In Witness whereof, the President and Secretary have set their hands and affixed the Seal of the Company this 17th day of October 1854.

Niagara Falls Hydraulic Company 1853

Capital 500,000 Dollars

Shares $100

E. S. King Secretary. [illegible] President.

Certificate for One Share of the Capital Stock of the Niagara Falls Hydraulic Company

Dated October 17, 1854

THE HYDRAULIC CANAL

1847–1918

CHAPTER IV

IN previous chapters, references have been made to the many endeavors of Judge Augustus Porter to promote the development of the power of Niagara's falling floods.

JUDGE PORTER'S PROSPECTUS OF 1847

During January, 1847, Judge Porter issued a circular[1] addressed "To Capitalists and Manufacturers" offering a canal right-of-way, approximately three-quarters of a mile long, extending diagonally from the river above the upper rapids to the edge of the cliff about one-half mile below the falls, to any persons who would immediately undertake the construction of the canal.

To the circular was attached a map[2] by P. Emslie, dated December, 1846, upon which was located the proposed canal and basin.

While this effort to interest capital did not meet with immediate response, it undoubtedly stimulated interest in the project and in 1852 the first serious attempt to progress this plan was made.

WOODHULL PROJECT OF 1852–1853

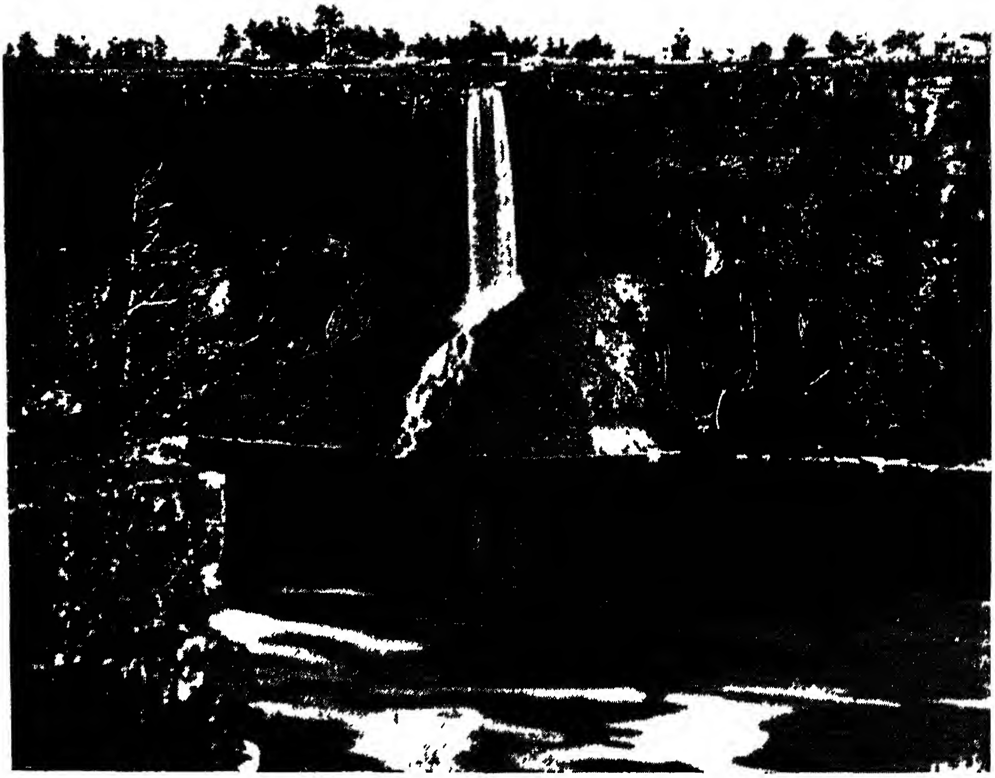
Caleb S. Woodhull of New York, and Walter Bryant and associates, of Boston, in 1852, entered into a contract with the heirs of Augustus Porter, the riparian owners, for the acquisition of the lands necessary for the intake to the canal on the upper river, the canal and terminal basin. The properties acquired by the Woodhull associates included: a plot of land, with its riparian rights, having a frontage of 425 feet on the upper river at the head of the canal; a right-of-way for the canal, 100 feet in width and approximately 4400 feet in length; and about 45 acres of land at the canal terminus fronting on the high bank of the river below the falls for nearly 1 mile.

The conveyance of land under this contract included only the lands to the edge of the high bank of the Niagara River and did not include the talus, or slope, between the edge of the high bank and the river, and only granted the right to excavate down the face of the bank 100 feet. These limitations of ownership were subsequently removed and full rights were acquired under the Schoellkopf management and ownership of 1877.

This enterprise was incorporated March 19, 1853, under the title of the Niagara Falls Hydraulic Company, popularly termed the "Woodhull Project." The objects of the company were stated to be "for the purpose of carrying on and conducting manufacturing, chemical and mechanical business

[1] Appendix C, Volume I.

[2] Chapter II, page 46.



1857

First Waters from the Hydraulic Canal Falling over the "High Bank," Unutilized

at the village of Niagara Falls by means of water-power drawn from the Niagara River immediately above the falls," and for the construction of a navigable hydraulic canal with its gates, bridges, wharves and other appurtenances. A printed prospectus, in pamphlet form, with two maps, was issued bearing the date of 1853.

The board of trustees comprised:

Walter Bryant	Caleb S. Woodhull	Stephen M. Allen
Daniel Badger	Alfred Ashfield	William Cockcraft
	Abram Wakeman	

and the officers were:

President: Caleb S. Woodhull,[1] of New York City
Secretary: Ezra S. King
Agent: Walter Bryant, of Boston
Chief Engineer: Charles Whitney

[1] Mayor of the city of New York, 1849–1850

1875

FIRST UTILIZATION OF THE HYDRAULIC CANAL FALLING OVER THE "HIGH BANK," BY THE GASKILL FLOURING MILL, USING ONLY 25 FEET OF THE 210 FEET AVAILABLE

The entire capital of $500,000 was paid in, according to the evidence said to have been duly filed with the clerk of Niagara County. A certificate issued for shares, showing the signatures of the president and secretary, is shown on page 68.

An issue of $200,000 5-year seven per cent convertible bonds was made in November, 1853, in the denomination of $500, "secured by a first mortgage on the Niagara Falls Hydraulic Canal and the lands, appendages and appurtenances thereunto belonging," upon the condition that no other bonds should be issued until after all this issue of bonds had been paid and cancelled.

The bonds were certified by Thomas McElrath, trustee of the mortgage.

1893

Manufactories of the Lower Milling District on the "High Bank" Served by the Hydraulic Canal, No Wheel Using the Full Head

1 *Central Milling Company*
2 *Niagara Wood Paper Company*
3 *Schoellkopf & Mathews Flour Mill*
4 *Pettebone Pulp Mill*
5 *Charles B Gaskill Flouring Mill*
6 *Niagara Falls City Water Works*
7 *Cliff Paper Company (first use of water, 75 ft head)*
8 *Cliff Paper Company, Lower Mill (second use of water, 125 ft head)*
9 *Oneida Community Mill*

Stephen M. Allen[1] at this time took a financial interest in the undertaking, which he had declined six years before, becoming one of the original party of four who commenced excavations. Ground was broken in 1853 and the

[1] Stephen M. Allen, self-described as an "old-fashioned engineer," of Boston, was acquainted with the Porter family and was familiar with the primitive methods of using water-power at Niagara by wooden overshot wheels in a loop canal, or raceway, paralleling the river along the upper rapids, and operating under very low heads. From 1835, Mr. Allen had experience in the utilization of water-power by manufacturers and in the building of mills, machinery and canals In 1847, he submitted to Judge Porter a sketch plan for the hydraulic canal project embodying the wheel-pit development of power. In 1884 Mr Allen stated, "Judge Porter made me a proposition to give me the canal and certain lands if I would build it, which I declined."

1926

THE GREAT SCHOELLKOPF ELECTRICAL POWER-PLANT AT THE FOOT OF THE "HIGH BANK" OF THE NIAGARA FALLS POWER COMPANY SENDING POWER TO HUNDREDS OF THOUSANDS OF USERS

work of excavation was carried on for about sixteen months, when it was suspended for lack of funds.

The plan of power development was described as a hydraulic canal 70 feet in width and 10 feet in depth, commencing on the Niagara River about half a mile above the rapids, and extending 4500 feet to a point on the bluff, about one-fourth of a mile below the falls, to its terminal in a basin, from which the waters discharged over a perpendicular bank about 210 feet high. The property rights acquired comprised (1) about 80 acres on the level plain or plateau below the falls, for manufacturing sites, extending about 1 mile on and along the high bank of the river, (2) 1100 feet of water front for wharf purposes, above the falls, opposite Grass Island, and (3) a strip of land 100 feet wide for the canal, the whole situated within the limits of the village of Niagara Falls, as will be seen by reference to the map on page 46. "All these lands," it was claimed, "including their water-privileges and other advantages, together with the exclusive right to construct the proposed canal, were

purchased by the company for the sum of $550,000, and are now absolutely owned by them." The Porter families are understood to have granted much of the right-of-way for the canal.

The excavation for the canal in limestone rock and the advantages of the canal in overcoming the danger from anchor ice were mentioned as features of the plan.

The population of the village of Niagara Falls in 1853 was probably less than 2000, and there were but few structures on the line of the canal, as it was located inland from the improvements that were then established near the river, in view of the rapids of the falls.

Charles H. Bigelow, chief engineer of the hydraulic works at Lawrence, Massachusetts, described in 1853 several patterns of water-wheels that he thought useful in developing the power at the manufacturing sites on the bluff. "More especially the turbine," he wrote, "is admirably adapted to this object; a wheel of this kind, which is about 13 inches in diameter, is now working in France under a fall of 354 feet and driving a factory of 8000 spindles."

ADVANTAGES OF NIAGARA POWER—PROSPECTUS OF 1853

The prospectus of 1853 called attention to the following as some of the advantages of the location:

1. No less than six railroads, all centering at this point, are now (1853) completed or in course of construction.
2. A commodious harbor may easily be made at the entrance of the projected canal; as a reef of rocks, over which there is only 3 feet depth of water, stretches out from the river bank just below that point, to an island (Grass) directly opposite extending some distance above it, therewith forming a natural barrier, which, at no great expense, may be rendered a complete breakwater. The wharves of the company will thus become safely accessible from Buffalo by vessels of the largest class; and canal boats, passing through the canal into the basin, will receive and discharge their freights at the very doors of the factories.
3. The proximity of the city of Buffalo is of itself sufficient to secure to it (Niagara) inestimable advantages as a manufacturing center.
4. Its attractiveness as a watering place will continue undiminished; for the proposed situation of the factories is such as to preclude the possibility of their detracting in the least from the grandeur of the cataract.
5. The celebrity which now attaches to the place, as the possessor of the sublimest of nature's works, will not be lessened when it shall be one of the great workshops of the world, sending forth daily the wonderful creations of human industry and skill.

This company did not meet with success. The cost of construction largely exceeded the estimates, and the capital available was insufficient to carry the construction to the production of income.

THE HYDRAULIC CANAL

DAY PROJECT OF 1856

In 1856, the name of the company was changed to Niagara Falls Water Power Company and the following named directors and officers were elected:

Directors

Stephen M Allen	James S. Greene	John Fisk
Horace H. Day	Alexander Hay	Parkhurst Whitney
	James Waldron	

Officers

President: Stephen M. Allen
Vice-president and Treasurer Horace H. Day
Superintendent: Alexander Hay
Hydraulic Engineer: L. M. Wright

This company, known as the "Day Company" under its new owners and management, acquired a moderate amount of additional capital, provided by Stephen M. Allen, who took full charge of the construction work until about 1860, when the control of the company was purchased by Horace H. Day. The entrance and river portions of the canal were completed in the spring of 1857. This condition was celebrated on July 4, 1857, as the "occasion of the opening of navigation to Niagara Falls," when three steamers, the pioneers in opening steam navigation from Lake Erie to Niagara Falls, came in procession to the mouth of the canal, then and now called Port Day. Water was allowed to pass through the canal for the first time on that day. The excavations permitting, commercial use was inaugurated the following year on the 4th of July, 1858, but the canal, as then projected, was not completed until 1862.

DAY PROJECT OF 1860

Since the company was unable to raise the additional money after the expenditure, it was reported, of nearly $300,000 in the work on the canal, the property was sold in 1860 to Horace H. Day, who reorganized the company under the title of Niagara Falls Canal Company and raised considerable money, which was expended mainly in blasting the rock for what is now known as the hydraulic canal from Port Day.

During the succeeding seventeen years, Mr. Day and his associates continued, from time to time, the excavation of the canal, and it was claimed in the spring of 1877 that the canal had been completed 1 mile long, cut through rock, with a capacity of about 27,000 horse-power. To carry the enterprise to this point, the owners had been obliged to borrow money and to secure the same by mortgage upon the property. In addition to the lands, water-rights

and mill-sites contributed by the Porter heirs, the total cash capital provided for construction work, in the water-power development from Port Day, by canal to the basin and mill-sites below the falls, between the years 1853 and 1876, has been estimated at more than $800,000 by successive promoters who failed in their efforts because of inability to provide the capital required for the completion of their respective undertakings, as well as lack of demand for hydraulic power for manufacturing uses.

Mr. Day stated that he had made every effort to protect the company's credit and had expended his entire fortune on the project. He had, however, been unable to raise any more money. The company had exhausted its resources and credit before the canal could be sufficiently extended to justify lessees in the construction of manufactories.

SCHOELLKOPF PURCHASE OF 1877

The company having failed to meet the interest maturing upon its bonds, its mortgage was foreclosed and its entire property sold at auction, May 1, 1877, for $71,000, the purchaser being Jacob F. Schoellkopf, and associates, of Buffalo. In a settlement of accounts with Mr. Day, a further payment of $5000 was made, making the total cost of the property to the purchasers, $76,000. This property consisted of the inlet from the Niagara River, called Port Day, the unfinished canal and the water-rights pertaining thereto, and about 45 acres of land on the cliff that have since been largely utilized for the canals and forebays of the manufacturing properties constructed there and operated by the water-power.

Much satisfaction was expressed by citizens of the village of Niagara Falls at the purchase of this hydraulic property by Mr. Schoellkopf, who was recognized as a progressive and successful merchant and manufacturer of Buffalo. As practical business men, he and his subsequent associates, with the courage of their convictions and the means to develop the power and the community of Niagara as they conceived it possible and profitable, were hailed as a favorable omen of progress and success for Niagara power. An old property owner declared when the sale was announced, "Now we can add a hundred dollars to the price of every lot."

GASKILL FLOURING MILL OF 1875

Prior to the purchase of the canal properties by the Schoellkopf associates, the first and only use that had been made of this water-power was in the flouring mill established in 1875 by Charles B. Gaskill. This was the first mill built upon the hydraulic canal basin, on the high bank below the falls.

It should be remembered that the early developments upon the hydraulic canal basin at Niagara Falls were begun before the engineers and the manufacturers dared to design and to build water-wheels for use under such high heads as were here available. Therefore, shafts, or pits, were sunk only to such depths, into the rock near the edge of the cliff, as were considered safe for the operation of the water-wheels then made. Turbines were first built of wood, later of wood and sheet iron, and still later bronze and steel were utilized.

The Gaskill mill employed a head of but 25 feet, thus utilizing less than one-eighth of the potential energy of the falling water from the upper to the lower river levels. Water was brought from the canal basin first through wooden flumes, later through iron tubes, to the turbines located at the bottom of the shafts. After passing through the wheel, the water escaped through short tail-race tunnels which discharged from the face of the cliff into the gorge below.

Reference to the illustration on page 71 will indicate how inefficiently these early developments used water, in the light of present-day knowledge and practise.

PROSPECTUS OF NIAGARA FALLS CANAL COMPANY

The new proprietors about this time issued an undated prospectus headed "Niagara Falls Canal Company" and bearing the names of J. F. Schoellkopf, A. M. Chesbrough, Stephen M. Allen and Miles Standish and offering for sale on reasonable and accommodating terms one hundred mill and factory sites and three hundred cottage lots. The description of the canal contained in this circular indicated the size and capacity of the canal then to be at its mouth 66 feet in width and 11 feet in depth. The average width of the main section of the canal was given as 22 feet, and the average depth as 10 feet.

Reference was made in detail to the facilities for the transportation of freight both by land and water, to the remarkably low taxation, and to the costs of living that were less at Niagara than in most manufacturing districts. The sites for manufacturing, it was stated,

> will be sold low according to location and size and the water at one thousand dollars per square foot of open weir surface at the head of the canal and the opening in the gates below to correspond in size to the square of water purchased

It was estimated that a square foot of water at the entrance of the canal, which would be one six hundred and sixtieth part of the whole inflow of water, with a velocity of 2½ feet per second, would give 41.67 horse-power, "a much more liberal estimate for loss of power upon water-wheels than is generally allowed," so the prospectus claimed.

[1] Appendix C, Volume I.

SCHOELLKOPF COMPANY OF 1878

A new company was incorporated by Mr. Schoellkopf in 1878 under the Business Corporation Law (Chapter 611) of 1875, under the name of The Niagara Falls Hydraulic Power and Manufacturing Company. This company acquired the canal property.

In this corporation Mr. Schoellkopf associated with himself George B. Mathews, of Buffalo, with whom Mr. Schoellkopf had been associated in the milling business, and also his son, Arthur Schoellkopf, who took up his residence in Niagara Falls and became the active manager of the hydraulic property, in which capacity he continued to act until his death in 1913.

SCHOELLKOPF AND MATHEWS FLOURING MILL

Following the acquisition of the property by The Niagara Falls Hydraulic Power and Manufacturing Company, the canal was improved and enlarged from time to time. The development of the property was inaugurated by the prompt erection by the firm of Schoellkopf and Mathews, between the canal and the top of the cliff, of a large flouring mill having a capacity of 1200 barrels of flour a day, and operated by 22 run of stones until 1881, when power for rollers was obtained from two "American" cast-iron turbine wheels producing 900 horse-power under a 50-foot head of water that was discharged down the bank 150 feet to the river below. The Schoellkopf and Mathews mill was shortly afterwards followed by another flouring mill constructed northerly of the other mill by substantially the same Schoellkopf interests, but under the name of Central Milling Company, using the water under a head of 80 feet.

The paper industry was the next manufacturing interest to utilize the canal water as its source of power. This naturally attracted and promoted the location of wood pulp factories and the manufacture of paper products.

THE HYDRAULIC CANAL COMPANY OF 1882

Under the stimulating example of Jacob F. Schoellkopf and his associates, other industries availed of the water-power of The Niagara Falls Hydraulic Power and Manufacturing Company, known as the "Schoellkopf" or "hydraulic" company.

The officers of this company in 1882 were:

President: Jacob F. Schoellkopf
Vice-president. William D. Olmsted
Secretary and Treasurer: Arthur Schoellkopf

The directors, in addition to these officers, were:

George B. Mathews
James Frazer Gluck

In 1882, the following named industries were using power furnished by the "hydraulic" company:

Title	*Industry*	*Horse-power*
Charles B. Gaskill	Flour Mill	100
Schoellkopf and Mathews	Flour Mill	900
Niagara Wood Paper Company	Pulp Mill	300
Cataract Manufacturing Company	Pulp Mill	1000
J. F. Quigley	Pulp Mill	250
Oneida Community, Ltd.	Silver Plating	150
Suspension Bridge	Village Water Works	25
	Total power	2725 h-p.

THE SCHOELLKOPF COMPANIES

Some time after this period the company announced its progress as follows:

> We are furnishing over 8000 horse-power.
>
> We have just completed the enlargement of our hydraulic canal, cut through solid rock, and we are now ready to furnish 40,000 horse-power under a head of from 100 to 200 feet. Without question this power will be constant and reliable in every way.
>
> We call your special attention to our latest development of power at the Cliff Paper Mill, using the water a second time under a head of 120 feet, and invite inspection

In the examination in 1884 of titles and values of the property and rights about to be acquired by the State of New York for its Niagara reservation,[1] the commissioners of appraisement held that "Niagara River is a public stream and its bed and waters belong to the State." The question of the company's riparian rights against the state was brought, in 1894, before the New York State Constitutional Convention. In 1895, the Attorney-General of the state rendered an opinion to the commissioners of the Niagara State Reservation adverse to the contentions of the company in respect to the right of the state to interfere with or prohibit the company's use of water.

By an act of the legislature of the State of New York, Chapter 968, laws of 1896, the right of the company

> to take, draw, use and lease and sell to others to use the waters of Niagara River for domestic, municipal, manufacturing, fire and sanitary purposes, and to develop power therefrom

was recognized, declared and confirmed.

For the first time the power of the Great Falls was successfully utilized, the manufacturing enterprises and the "hydraulic" company were profitable,

[1] See Chapter VI, "State Reservation at Niagara."

the population of the village of Niagara Falls increased and its prospects were recognized as attractive, as an industrial as well as a scenic center.

SUCCESSFUL USE OF THE HYDRAULIC CANAL

In 1881, the first hydro-electric generating station was established on the hydraulic basin to supply electricity for commercial purposes. This station was located in what was then known as Quigley's Mill, later the Cliff Paper Company's Mill. In this station there were installed water-wheels operating under a head of about 86 feet. These wheels operated the paper mill, several small factories and an arc light machine owned by the Brush Electric Light and Power Company, which concern had been organized in November, 1881, by Jacob F. Schoellkopf, George B. Mathews, W. D. Olmsted, Arthur Schoellkopf and Benjamin Rhodes. The December 14, 1881, issue of the *Gazette,* Niagara Falls' weekly newspaper, said:

> No sooner was the announcement made through the columns of the *Gazette* that an electric light company had been formed in the village for the purpose of supplying our stores and manufacturers with light, than applications began to pour in, and the company has been busy filling the orders. This evening (Wednesday, December 14, 1881), the company will furnish light for the Schoellkopf and Mathews grist-mill, J. Quigley's pulp mill, Oneida Community Building, Marr & Duff's dry goods store, H. E. Griffith's drug store, S. Hirsch's dry goods store, and the *Gazette* office.

The first arc-light machine installed in this electrical development weighed 2250 pounds and delivered sufficient electricity to operate sixteen 2000 candle-power open arc lamps which were used to furnish street and store service. This use of hydraulic power, converted into electric light, was the first public distribution of electricity at Niagara Falls, and it stimulated interest in the development of power in general at Niagara.

In 1886, The Niagara Falls Hydraulic Power and Manufacturing Company secured a deed for the slope or strip of land between the high bank and the lower river, that was not included in the original grants acquired from the Porter family. The value of this strip for every purpose in the development and use of power was thus early recognized.

MILLING DISTRICT OF 1893

By an examination of the view of the "Milling District," in 1893, on page 72, it will be noticed that in no instance was the power fully utilized, or even half used, as the available fall was about 210 feet, while the water-wheels were installed at a comparatively short distance down the cliff, the earliest of iron, at 25 and 50 feet, and subsequent wheels, of iron and bronze, under greater heads.

THE SCHOELLKOPF POWER STATIONS

FULL HEAD IN USE, 210 FEET FROM CLIFF TO GORGE

During 1895 and 1896 The Niagara Falls Hydraulic Power and Manufacturing Company constructed its Power Station Number Two[1] at the water's edge in the gorge, designed to use water under the full available head of 210 feet. In the first section of this station were installed four double discharge turbines, built by James Leffel & Company, of Springfield, Ohio. These four turbines had a total capacity of 6850 horse-power, and were supplied with water through an 8-foot diameter steel penstock extending from the forebay at the top of the cliff to the power-house below.

The first section of the full head development proved so successful that two more sections were immediately added, making a station 170 feet long by 100 feet wide, of fire-proof construction being built entirely of stone and steel. The equipment of the completed station consisted of fifteen turbines, the capacities of fourteen of them ranging from 1600 to 3500 horse-power, the combined output capacity being 34,000 horse-power. The turbines of the two sections of Power Station Number Two last built received their supply of water through steel penstocks 11 feet in diameter. In respect to the power capacity, these penstocks were then the largest in the world.

In the light of present central station practise, it is interesting to review in brief detail the installations made in Hydraulic Station Number Two.

Not only was it possible in this station to utilize the full effective drop of 210 feet between the head of the upper rapids and the Maid-of-the-Mist pool below the cataracts, but it was also possible to use horizontal shafts directly connecting turbines and generators which practically eliminated all bearing troubles.

To each turbine was attached two or more generators. The Pittsburgh Reduction Company (now the Aluminum Company of America) received the output of six 560-kilowatt, eight 750-kilowatt and four 1000-kilowatt generators, delivering direct current at 300 volts. These eighteen generators were all of Westinghouse design and manufacture, and aggregated 13,360 kilowatts or about 18,000 horse-power.

The National Electrolytic Company, engaged in the electrolytic manufacture of chlorate of potash, 2500 horse-power, taking the output of one 200-kilowatt, 135-volt, direct-current, and two 875-kilowatt, 175-volt, direct-current generators; all designed and produced by the General Electric Company.

The Acker Process Company utilized an aggregate of 3800 electrical horse-power delivered in the form of direct current at 325 volts by three 1000-kilowatt, 3100 ampere, General Electric generators.

[1] Since abandoned.

One turbine drove two 560-kilowatt, 550-volt, direct-current generators of General Electric make. One of these generators carried a commercial load, supplying current to about fifty small users of power. The other generator carried a railway load, for the operation of the Niagara Gorge Railroad.[1] A booster with a range of 300 amperes was attached, and in circuit with the Youngstown and Lewiston electric railroad 14 miles distant from the power-house.

Two 1000-kilowatt, 11,000-volt, 3-phase alternators, manufactured by the Bullock Manufacturing Company, supplied 25-cycle current for transmission to customers located at various distances up to 2 miles. One 700-kilowatt, 2200-volt, single-phase alternator made by the Walker Manufacturing Company was operated for the Buffalo and Niagara Falls Electric Light and Power Company which company was the distributing agent of Niagara power for commercial and municipal lighting in the city of Niagara Falls.

It is interesting now to note that of the total capacity of Hydraulic Station Number Two, amounting to 34,000 horse-power, approximately 90 per cent was used for generating direct current, and but 10 per cent for alternating current. Today, the ratio is reversed, slightly more than 90 per cent of the system output being alternating current.

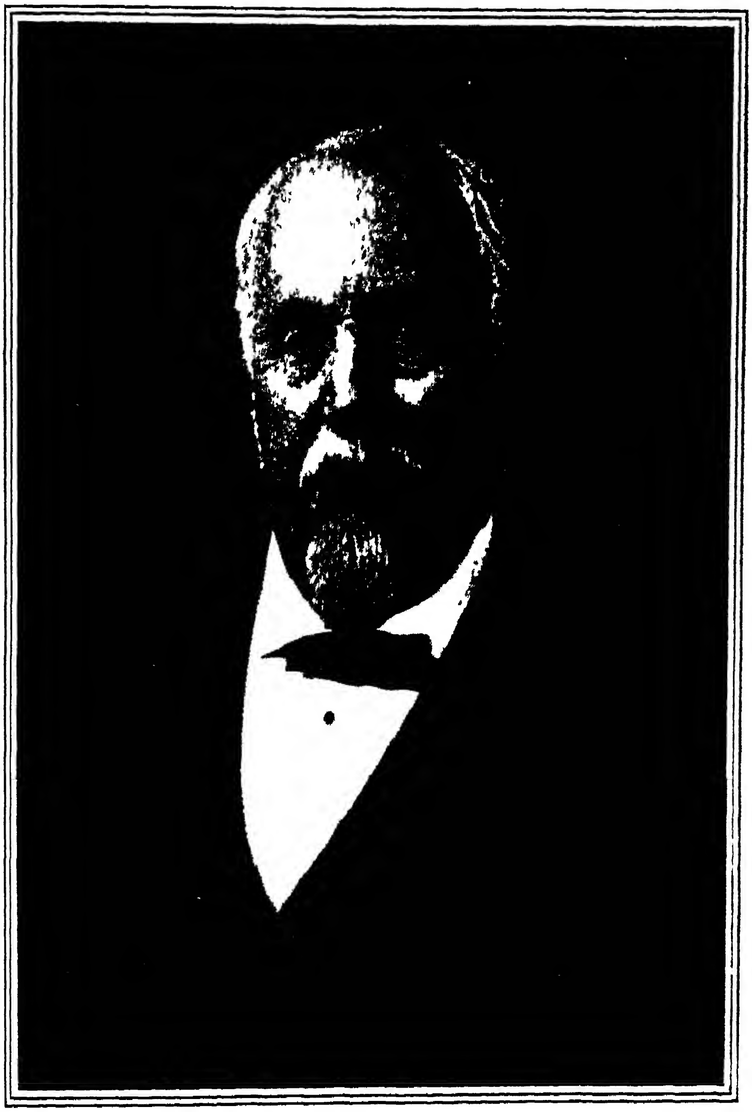
The "hydraulic" company began the building of its Station Number Three-A in 1903 and completed it in 1913. The equipment consisted of thirteen double-runner, 300 r.p.m., 10,000 horse-power turbines and two single-runner, 500 r.p.m., 1000 horse-power turbines, all horizontal shafts, furnishing mechanical energy for the operation of generators. These turbines all operated under an effective head of 210 feet. The electrical equipment of this station was made up of eight 8000-kilowatt, 12,000-volt, 3-phase, 25-cycle; two 1000-kilowatt, 2200-volt, 3-phase, 25-cycle; and ten 3500-kilowatt, 550-volt direct-current generators. The ten direct-current generators were connected to five water-wheel shafts, two generators to one shaft. The total rated installed capacity of Station Number Three-A was 132,000 horse-power.[2]

THE SCHOELLKOPF PIONEER

Jacob Frederick Schoellkopf located his home and business in Buffalo in 1844, where as a leather manufacturer he became one of the successful men of that community. After his purchase in 1877 of the hydraulic canal at Niagara Falls, and the transfer of the canal property to The Niagara Falls Hydraulic

[1] The Niagara Gorge Railroad was purchased by The Niagara Falls Power Company during January, 1925.

[2] For table showing installed rated capacity of later Schoellkopf installations, see Appendix P, Volume II



Jacob Frederick Schoellkopf

Born in Kirchheim, Germany
November 15, 1819

Died in Buffalo, N. Y.
September 15, 1899

Founder in 1877 of
The Niagara Falls Hydraulic Power and
Manufacturing Company

Whose Foresight and Courage Laid
the Foundation for the Power Development
at Niagara Falls

Power and Manufacturing Company in 1878, he became its president, an office he held until his death, September 15, 1899.

His life was one of industry, courage and patience, and his enterprises testified to his forethought. He succeeded where others had failed.

The industries he established in the utilization of the waters of Niagara constitute a monument to his leadership and influence in the upbuilding of the city of Niagara Falls, and in the commerce of that community.

His will expresses his confidence in the future of the hydraulic company by the provision that the interests he bequeathed should not be sold for a period of years after his death.

Upon Mr. Schoellkopf's death in 1899, George B. Mathews of Buffalo became president of the hydraulic company, and Arthur Schoellkopf, of Niagara Falls, continued as the active manager of the property. The successful development of the properties of the company continuously progressed under the guidance of Mr. Mathews and Mr. Schoellkopf, until the death of Arthur Schoellkopf in 1913 and the retirement of Mr. Mathews in 1914. Thereafter the management of the property devolved upon several members of the family of Jacob F. Schoellkopf, Sr. Among those most active therein were Jacob F. Schoellkopf (his son), the present chairman of the board of directors of the consolidated company; Paul A. Schoellkopf, the present president of the consolidated company, son of Arthur Schoellkopf, and grandson of the first Jacob F. Schoellkopf; and Alfred H. Schoellkopf, vice-president of the consolidated company, another grandson of the first Jacob F. Schoellkopf, and the son of C. P. Hugo Schoellkopf, who has also for many years been active in the affairs of the hydraulic company and the consolidated company.

THE HYDRAULIC CANAL

SUMMARY OF OWNERSHIPS

1853–1918

The project of a short hydraulic canal to a forebay on the bluff proposed by Stephen M. Allen in 1847 to Judge Augustus Porter, passed into the ownership of various companies under the following successive titles:

1853—Niagara Falls Hydraulic Company

known as the "Woodhull project."

1856—Niagara Falls Water Power Company

known as the "Day" company.

1860—Niagara Falls Canal Company

known as the "Day" company.

1878—The Niagara Falls Hydraulic Power and Manufacturing Company

known as the "hydraulic" canal,
or "Schoellkopf" company.

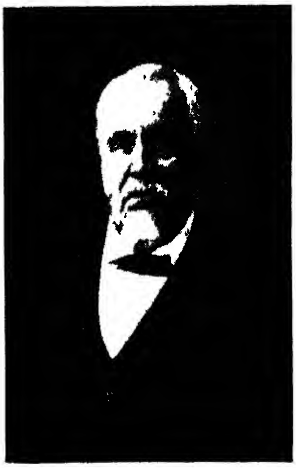
1909–1910—Hydraulic Power Company of Niagara Falls
Cliff Electrical Distributing Company

known as the "Schoellkopf" companies.

1918—The Niagara Falls Power Company, MCMXVIII

known as the "consolidated" company, under the control and management of the Schoellkopf family and their associates.

ARTHUR SCHOELLKOPF
1856-1913



JACOB F. SCHOELLKOPF, I
1819-1899

JACOB F SCHOELLKOPF, II

PAUL A. SCHOFLLKOPF

ALFRED H. SCHOELLKOPF

C. P. HUGO SCHOELLKOPF

JACOB F. SCHOELLKOPF, III

THREE GENERATIONS OF THE SCHOELLKOPF FAMILY

For three generations the Schoellkopf family have been engaged in power development at Niagara Falls, the first Jacob F. Schoellkopf having founded The Niagara Falls Hydraulic Power and Manufacturing Company in 1877, and having continued as president of this company and its successor, the Hydraulic Power Company of Niagara Falls, until his death in 1899 The record of his sons and grandsons follows: Jacob F. Schoellkopf, II, son of Jacob F., I, president, Hydraulic Power Company of Niagara Falls, 1914 to 1918; chairman, board of directors of The Niagara Falls Power Company, 1918 to date, chairman, board of directors of Buffalo, Niagara and Eastern Power Corporation, 1925 to date; Jacob F. Schoellkopf, III, son of Jacob F., II, director of The Niagara Falls Power Company, 1918 to date; director, Buffalo, Niagara and Eastern Power Corporation, 1925 to date; Arthur Schoellkopf, son of Jacob F, I, secretary and treasurer, The Niagara Falls Hydraulic Power and Manufacturing Company, and its successor, the Hydraulic Power Company of Niagara Falls, 1877 to 1913; Paul A. Schoellkopf, son of Arthur, vice-president, Hydraulic Power Company of Niagara Falls, 1913-1918; president, The Niagara Falls Power Company, 1919 to date; president, Buffalo, Niagara and Eastern Power Corporation, 1925 to date; C P Hugo Schoellkopf, son of Jacob F., I, vice-president, The Niagara Falls Power Company, 1918 to 1926; vice-chairman, board of directors, The Niagara Falls Power Company, 1926 to date; director, Buffalo, Niagara and Eastern Power Corporation, 1925 to date; Alfred H. Schoellkopf, son of C. P. Hugo, vice-president, The Niagara Falls Power Company, 1920-1926; vice-president and general manager, Buffalo, Niagara and Eastern Power Corporation, 1925 to date.

PROJECTS THAT FAILED TO MATERIALIZE

Chapter V

PROJECTS THAT FAILED TO MATERIALIZE

CHAPTER V

UP to this point, the course of Niagara's material advance has been followed as it would have revealed itself to a visitor returning to the great cataract from time to time through the century following the American Revolution.

Petty uses of power by a few individual mills located on the raceway loops, upon the river bank above and near the falls, satisfied their meager requirements from the waters of the upper rapids, as if from an ordinary river, without drawing upon the vast abundance of the Great Falls.

The lack of financial resources was indicated by the slow progress of the "hydraulic" canal, built in portions, under the administration of four successive companies, three upon the wrecks of the fortunes of their predecessors.

The inauguration of a new period of local prosperity was stimulated by the so-called completion of the canal, which made available the entire head of the falls for such use as the manufacturer could make of it.

These were the developments that had actually stamped themselves upon the landscape of Niagara.

In order to gain a true perspective of the Niagara problem, it may be helpful to take account also of several futile projects which were brought forth during that period for the utilization of the waters of the river, and to consider the reasons why they did not come to a successful issue.

TRANSPORTATION PROJECTS

From the time of the first voyageurs, the falls had always been a great obstacle upon the main trade-route to the West. The increase of commerce between Lake Ontario and Lake Erie, on its way between the East and the growing West, and the necessity of using the Niagara portage, prompted consideration of the means whereby the portage around the falls and rapids might be avoided and such transportation cheapened and quickened by the use of a barge canal to be constructed.

NIAGARA CANAL COMPANY OF 1789

The earliest of these projects had for their chief object an effective means of water transportation between the Great Lakes, with the development of power as merely incidental to this purpose.

Appeals were made to the state legislature for relief. Upon representation that the route was feasible and "would tend greatly to facilitate and advance the internal commerce of this state and promote the convenience and

prosperity of the people thereof," a charter was granted April 5, 1789, to the Niagara Canal Company with authority to construct a canal beginning at or near Steadman's landing, about 2 miles above the falls of Niagara, to a convenient place below the falls, at Lewiston, opposite Queenstown, a distance of about 7 miles, with all locks, dams, works and devices necessary for "complete navigable water communication" between the said places; also "to take the water from the channel for mills and other hydraulic works which may be erected or constructed by the company and to lease the use of the water for any lawful purpose."

The company was further authorized to condemn land and to use so much of the land belonging to the people of the State of New York as might be necessary for canal and locks and also 100 feet in width on each side of the said canal for towing paths, and other incidental purposes.

This is the first reference in state legislation to the use of the waters of the Niagara River. The primary object, it will be noted, was navigation, the development of power being merely incidental.

By the terms of its charter the company was required to complete the canal and locks by January 1, 1809. It does not appear that this undertaking ever reached the stage of actual construction; and from the fact that the same name, Niagara Canal Company, was given to a new corporation under a legislative act of April 11, 1823, it may be inferred that the charter of the old company expired by default.

NIAGARA CANAL COMPANY OF 1823

Authority to build a canal was granted for the purpose of opening navigation from above the falls, beginning at or near the mouth of Gill Creek in the town of Niagara, to the heights overlooking Lewiston, and to construct a railway from there to the navigable water of the Niagara River nearly opposite Queenstown. The company was also authorized

> to take the surplus water which shall be contained in any lock, bay, pond, or embankment, or other improvement made by the said company, and make use of the same . . . for mills or any other hydraulic works which may be erected or constructed by the company.

> To enter upon, possess, and occupy any lands near the north termination of said canal and railway, either on the side of the mountain or stony flat below, that shall be necessary to erect mills for any hydraulic works, with full power to make all dykes, ponds, embankments, raceways, tail-races, roads, bridges and gates.

The company was authorized to impose a toll for the use of navigation not exceeding

> fifty cents per ton for all property carried on the canal through the whole distance thereof.

It was also enacted that the legislature might

> dissolve the company, when the income arising from the said tolls shall have fully compensated the said company for all necessary expenditures, together with an interest of fourteen per cent per annum,

and

> in case the said company shall fail or neglect to complete the said canal, ... within ten years from the passing of this act, then and from thenceforth all and every right, privilege and immunity granted and secured by this act, shall cease and terminate

Bates Cook, Robert Fleming, William Hotchkiss, Ames S. Tryon and Rufus Spalding were appointed commissioners to offer publicly for subscription the capital stock authorized, not exceeding $120,000, in shares of twenty dollars each, payable at par as the commissioners might prescribe, in labor on the canal, in materials, in provisions, or in money.

By comparing the charters of 1789 and 1823 it will be observed that the earlier grant was for a complete navigable water communication by canal with locks and dams, from Steadman's landing to a convenient place below the falls opposite Queenstown The Act of 1823 authorized a company with the same name to build a canal, for the purposes of opening navigation from Gill Creek above the falls and near Steadman's landing, to the heights near Lewiston. In the latter case, no dams and locks were authorized or apparently contemplated, to extend the navigation down to the level of the lower Niagara River. It is evident that locks to overcome the difference in elevation of 316 feet between the water level of the upper river and the river below the falls near Queenstown, the port of Lake Ontario, had been found impracticable, and the remainder of the portage was expected to be accomplished by a transfer by railway of merchandise and passengers from boats in the canal terminus at the bluff overlooking Lewiston, to the navigable water of the Niagara River nearly opposite Queenstown.

This act also provided that if the canal authorized was not completed within ten years, all the rights granted should cease. There is no evidence that any serious work was done on the canal or railroad. As the canal route would have required rock excavation for its entire length of approximately 6 miles, the construction project was as impracticable an undertaking as that of the Act of 1789, excepting that a railway was authorized instead of locks to overcome the difference of elevation between the terminals. It may be observed that the provision for a railway in the Act of 1823 antedates by several years the commercial advent of the locomotive in America.

These charters granted by the State of New York for the development, primarily, of water transportation, and, incidentally, of power, had not offered

sufficient inducement to secure the necessary investment of capital. No work was performed under them. It may be concluded that in each case the estimated cost of excavating such a canal through 6 miles of solid rock proved discouraging, and led to the abandonment of the undertakings. It would not pay.

OTHER SHIP CANAL PROJECTS

Several national projects were seriously considered for a ship canal around Niagara Falls. From 1808 to 1863, resolutions were passed, surveys ordered and reports made, but Congress failed to make an appropriation for construction, which was variously estimated by the engineers employed, at from $1,000,000 to $3,000,000. The routes were mainly from above the falls to the vicinity of Lewiston. No such construction was authorized or provided for then or since.

The completion of the Erie Canal in 1825, with a harbor on the Niagara River, near Buffalo, and the construction of railroads approaching Niagara Falls, put the Niagara portage into disuse, and turned the thoughts of those interested in the utilization of the waters of Niagara River from the facilities of transportation to the development of power.

NIAGARA RIVER HYDRAULIC COMPANY, 1832

The first united effort to utilize the power of the Niagara River as a main purpose, apart from transportation, appears in the incorporation of the Niagara River Hydraulic Company, April 11, 1832. This was a project for a hydraulic and manufacturing development at Squaw Island, near Buffalo, at the junction of the Erie Canal with the Niagara River, bordering on its eastern shore and upon the "Pierpont Harbor" and the lower "Black Rock Harbor." The water-power available at this island was comparatively small. Although the location was some distance from the falls, the development of this project was thought to be detrimental to the further settlement, at that period, of the town of Niagara Falls.

A map was prepared showing the entire island, laid out in mill-sites and residential lots, under the name of: The Village of Pierpont on Squaw Island, owned by Ogden Edwards and Henry F. Penfield.

The explanation of the map follows:

The Blackrock Harbour has created a water-power at this point of five feet Head and Falls. It is at the foot of a ship navigation of 1000 miles and at the Commencement of the Grand Canal. The Mill Lots are all 100 feet broad and from 150 to 200 feet deep or long. The Building Lots are 50 by 100 feet. The Streets are 60 feet wide, excepting adjoining the mill seats, where they are 30 feet wide. The blocks are 400 by 200 feet. There is a Horse Boat Ferry from Pierpont to Canada and it is connected with the Maine by a Dam seventy feet wide and a free Bridge.

It is worthy of note that those streets called Bre(a)ckenridge, Porter and Barton bore the names of engineers of The Niagara Falls Power Company engaged in construction work at Niagara Falls during 1890–1895.

The Squaw Island project never reached the stage of actual construction.

THE FANNING CANAL-TUNNEL SCHEME

Lewiston Water Supply Company, 1888

One of the most comprehensive and expensive of the many projects submitted by engineers of recognized ability and experience was that proposed in the latter part of the year 1888 by J. T. Fanning, chief engineer of the St. Anthony Falls Water Power Company, of Minneapolis, Minnesota, acting in behalf of the Lewiston Water Supply Company[1] whose charter, capital stock, franchise, project, plans and property were acquired by The Cataract Construction Company in February, 1890.

The Fanning project possessed many features of the "hydraulic" canal, and of the discharge "tunnel" plan of Evershed, but the length of each element was much greater. It included what the others did not, a canal or inland harbor, 600 feet long, 150 feet wide and 20 feet deep, with 4 miles of wharfage front for the terminal accommodation of lake shipping The canal system was projected to supply a large number of water-wheels which were to discharge their water through a system of tunnels into the lower river.

Mr. Fanning concluded a statement regarding the project as follows:

> There is no water-power where the expense of repairs, attendance and supplies can be reduced to so low a minimum.
>
> There is no large water-power in America so well protected from destructive effects of running logs and ice or from the breaking of dams higher up the stream, or having such probable immunity from accidents, or having so many elements of safety and permanence.
>
> There is no site of a large water-power having equal facilities to receive all kinds of raw materials in large abundance at so low a cost, no site that can receive common or skilled labor with greater facility, or that can send its manufactured products to such a variety of large markets with greater facility, and there is no large water-power site in America where development gives greater promise of both practical and financial success.

Niagara was not to attain her true destiny under this regime. The potentialities of the great cataract far transcend any scheme for utilization of power restricted by the methods then in use. This project is interesting because it represented a full development of water-power enterprises in this country at that period, that were based upon the long-used system of building a mill over a wheel-pit—a method that received its knell at Niagara in 1890.

[1] Charter expired in 1898 for non-use.

$100,000 PRIZE FOR NIAGARA POWER AT BUFFALO

Among the citizens of Buffalo who appreciated the advantages that would accrue to their city if the power of the Niagara River were put to practical use in that community were Messrs. Richard H. and James B. Stafford, proprietors of the "Famous Fulton Market," situated at the corner of Church and Pearl streets. It occurred to these gentlemen that if a sufficient inducement were offered to enlist the interest of engineers and inventors in the problem, some hope might be entertained of a satisfactory solution in which their fellow-citizens might profit.

They accordingly opened a subscription list for the creation of a fund of $100,000 for this purpose, and by their personal efforts succeeded in obtaining 110 subscriptions aggregating $109,500. Following is the form of subscription and the list of subscribers, all, with one exception, for $1000 each:

BUFFALO, N. Y. JULY 14th, 1887.

The undersigned agree to pay the sums set opposite their names respectively, in the manner hereinafter stated, to a fund, which shall constitute a prize or reward, to be offered to the inventors of the World, for the discovery or invention, and sole right to use the same, of the best appliance for utilizing and one that will utilize it commercially, the water-power of Niagara River, at or near Buffalo, so that such power may be made practically available for various purposes throughout the city None of the subscriptions hereto shall be payable unless the aggregate sum subscribed shall amount to at least one hundred thousand dollars, and when that amount is subscribed, a meeting of the subscribers shall be called, at which meeting each subscriber may cast one vote for every fifty dollars he has subscribed. Such meeting shall determine the specific terms and conditions on which the offer of said prize or reward shall be published to the world, and shall determine the manner and time of payment of the subscriptions hereto.

Adams, James
Barnard, Jos. E.
Barnes, Hengerer & Co.
Barr, G. D.
Bishop, Chas. F.
Box, Henry W.
Brady & Drullard
Brayton, S. N., M.D.
Briggs, G. D.
Burns, Millard S.
Bush, John W.
Busch, Fred
Butler, E. H.
Campbell, John A.
Cook, P. N. & Co
Coppins, Frank T.
Cowles, S. H.
Curtiss, C. G.
Cutler, A. & Son
Davis, W. H.
Dimick, Lorenzo
Dingins, John C.
Eagan, S. F.
Emmet, J. K.
Fargo, F. F.
Ferris, P. J.
Germain, G. P
Graves, John C.
Greene, Samuel B.
Hagen, F. P.
Hamlin C. J., Wm. & Harry
Hammond, S. W.
Harrington, D. W.
Harvey & Henry
Hautmann, F. J.
Hefford, R. R.
Heimbruch & Hodge
Hodson, Matthew
Howard, Geo. R
Howard, R. L.
Hughes, John
Inglehart, F. M.
Irlbacker & Davis
Johnson, W. H.
Kent, H. M.
King, Wm. J.
Kirkbauer, H. D.
Kittinger, Joseph
Koons, Henry
Lautz, Chas.
Lautz, Fred C. M.

LIST OF SUBSCRIBERS—*continued*

Linen, John R.	O'Day, Daniel	Smith, Wm. B.
Locke, Franklin D.	Onello, Lewis	Stafford, Jas. B. & R. H.
Loh, Fred C.	Palen, M.	Stafford & Co.
Loomis, Frank M.	Palen, Robert	Storer, Samuel L.
Lyman, C. M.	Partridge, G. W.	Sweet, C. A.
Lyth, Jno. & Sons	Pooley, Chas. A.	Swift, H. J.
Lytle, Chas. P.	Potter & Williams	Taylor, H. L.
Mack, Norman E.	Pratt, P. P.	Taylor, R.
Marshall, Chas. D.	Ratcliffe, S. M., Jr.	Thomas, J.
Martin, John	Rebstock, J. E.	Thorn & Angell
McMillan, Daniel H.	Reilly, Wm. B.	Wadsworth, H. C.
McMullin, Fred L.	Richardson, Chas.	Walker, Wm. H.
Mills, Edward P.	Rockwood, E. A.	Warner & Co.
Moore, J. Lansing	Rumsey, D. P.	Weill, Henry & Co.
Morgan, D. E. & Son	Sandrock, George	Wennell, Michael
Morgenstern, Jacob	Satterfield, John	Winnan, Erastus
Movius, E. H.	Schaefer, G. A.	Wood, W. E.
Nagel, Jno. C.	Scheu, S.	Wright, A. P.
Nellaney, M	Sherman Bros. & Co. Ltd.	Zink & Hatch
Oatman, Leroy	Smith, John H.	

The local newspapers supported the idea enthusiastically by communicated articles and by editorials, and the scheme soon attracted world-wide publicity. Projects were submitted in ever-increasing number, the mail becoming so heavy that a society, the Buffalo Business Men's Association, was formed under the presidency of James B. Stafford to take care of it, with Peter J. Ferris, one of the subscribers, devoting his entire time to the matter as secretary of the association. The whole third floor of the Fulton Market Building, on Pearl Street, was used as a storage and exhibition place for the models which were brought in by the inventors or received by express.

At about this time, a fair was being held at the Hamlin Driving Park, through which flowed the Scajaquada Creek. The various inventors were invited to take this opportunity of testing their models in the creek to show how they would perform under natural conditions. Many of the inventions failed utterly under the tests, and none succeeded in convincing the subscribers of their merit.

NIAGARA HYDRAULIC ELECTRIC COMPANY, 1887

One of the results of the interest thus awakened in the Niagara River was the formation of the Niagara Hydraulic Electric Company, a Virginia corporation with authorized capital stock of $20,000,000, which had for its object a great development of power by means of hydro-electric machines to be located in caves excavated behind the falling water at the great cataract, in such a way as to utilize the water without diverting it. The Messrs. Stafford

were much interested in this scheme, and gave its promoters their active support, until convinced by a visit from Peter A. Porter of Niagara Falls, who was promoting the plan of Thomas Evershed, which will be fully dealt with in a later chapter, that the latter project was far more promising of practical success.

The Business Men's Association was therefore dissolved, without debts and without having called upon its subscribers for any money. The effort, however, was a demonstration of the public sentiment of many influential citizens in Buffalo and was considered as an urgent invitation to extend a power line to that city at the earliest opportunity.

"THE MODEL CITY—NIAGARA POWER DOUBLED"

Under the foregoing title, a prospectus of thirty-two pages issued in 1893 presents a sample of projects of another character. The word Niagara, suggesting such related words as colossal, inexhaustible, opportunity, power, fortune, was a word with which the promoter could conjure.

The project mainly sought, first, to develop 15,000 acres of land bordering on Lake Ontario and extending southward to Lewiston and, second, to build a power canal to take water from the Niagara River, east of the town of La Salle and to conduct it to the lands of the company and its manufacturing districts, providing power by a fall at the escarpment or Niagara terrace.

The following statements were among those used to emphasize the commendation of the investment by its promoters:

> Nothing approaching it in magnitude, perfection or power has ever before been attempted.
>
> If you intend to invest, do so promptly, take advantage of "first prices" and "choicest locations" and thus control "the largest possible profits" with the amount of money at your command.
>
> Our vast Development Fund of $25,500,000, our cheap homes for workmen, our "free sites, free power" and other advantages "practically guarantee success" and "rapid development" such as no other city in the world ever experienced.
>
> Risk of loss is entirely eliminated. There is no risk and a compound accumulative profit in the earliest investment.
>
> We do not urge any one to invest, wishing only to call attention to the foregoing facts that you may be able to place yourself among the most favored ones in the enterprise if you wish to do so.
>
> Designed to be the most perfect city in existence.
>
> Unlimited water-power. Superlative conditions. Foresight. Investments. Profit-sharing Plants.

The company did some work of construction upon the sections of its canal at the proposed inlet and the outlet at the escarpment. The companies became bankrupt, and the moneys invested in the enterprise were lost.

FUTILE PROJECTS AND PROJECTS WHICH HAVE PERSISTED

The consideration at Buffalo in 1882 of a sewerage system and of the issuance of $3,000,000 of city bonds for its cost led to a project widely advertised that was intended to avoid the necessity of issuing these bonds. It was hoped thereby to combine the flow of sewerage with that of the waters of the lake in a tunnel that would discharge under the falls of Niagara and develop a water-power for manufacturing upon a large acreage secured on Grand Island for factory sites. This was called a splendid dream for the utilization of Niagara power. Practically it was a diversion of a large amount of water from the falls to a sewerage discharge below the falling waters taken from the mouth of the river at Buffalo. The enterprise was forecast as a magnificent sewerage system for a city with a population of five million and the erection of thousands of mills and factories. Although this project received recognition from the city government that appointed a committee of seven citizens for the purpose of making a report on the feasibility and desirability of the proposal, it also failed to materialize and the city of Buffalo was obliged to pay for its own sewerage system.

Inducements to invest at Niagara were seldom accompanied by explanations of physical difficulties that were almost insurmountable and impediments which awaited the development of scientific knowledge, invention and engineering skill.

These impediments challenged conquest.

Many new actors, novel projects, and startling inventions will appear as the records of a decade are uncovered by succeeding chapters.

The interest in power development on a large scale near Niagara Falls has been related in the account of the hydraulic canal in Chapter IV. The evolution of the Evershed tunnel project, the second of the great power projects which has persisted, will be told in Chapter VIII.

The futile efforts of the pioneer years are now all but forgotten. Their rehearsal is of historic interest and it shows how long and disappointing was the road to success. Even $100,000 reward for a method of bringing power from Niagara to Buffalo brought forth no practical plan in 1887; such an achievement at that time was unattainable. Yet in less than a decade the commercial transmission of power to Buffalo was inaugurated, on a scale then unprecedented, and by the method now universally employed for the long-distance transmission of power.

STATE RESERVATION AT NIAGARA

1869

1879–1885

Chapter VI

Niagara does not belong to Canada or America. Such spots should be deemed the property of civilized mankind; and nothing should be allowed to weaken their efficacy on the tastes, the morals and the enjoyment of all mankind.

Andrew Reed and Thomas Matthewson
Delegates to the
Presbyterian Churches of America
1834

The history of Industrial Niagara is the history of one of the most vital economic developments of the age. More than one important industry has been entirely revolutionized by the application of Niagara power.

Charles Mason Dow
Commissioner of the
State Reservation at Niagara

STATE RESERVATION AT NIAGARA

Suggested in 1869, Officially Proposed in 1879, Made Free, July 15, 1885

CHAPTER VI

PROPOSAL OF RESERVATION

THE first recorded mention[1] of attention being called to "the rapidly approaching ruin of the characteristic scenery of Niagara," was in 1869, when Frederick E. Church, artist, mentioned it to Frederick Law Olmsted, landscape architect, both Americans. During the following years to 1879 the desecration continued with a retarding influence upon the tourist visitations, and the subject of the preservation of the falls and its natural setting was agitated with evidence of an increasing public interest. Notwithstanding a vigorous and well-organized campaign, under experienced and recognized leadership, it was difficult to persuade the legislators at Albany that it was wise and prudent to purchase Niagara Falls and its surrounding property on the American side, for which many millions of dollars were demanded while the constitutional debt limit of the state permitted the increase of its total bonded indebtedness at that time by only $1,000,000. It required seven years of strenuous effort to educate and persuade the state legislators that the people they represented were intent upon having "Niagara made free," as the slogan expressed the public purpose.

The official procedure commenced with the appeal of Lucius Robinson, governor of the State of New York, in his annual message of January 7, 1879, when he stated:

> The civil jurisdiction over the Falls of Niagara as well as the shores and waters of the Niagara River is divided between this State and the Province of Ontario, in Canada. But, in one sense, the sublime exhibition of natural power there witnessed is the property of the whole world. It is visited by tourists from all quarters of the globe, and it would seem to be incumbent upon both governments to protect such travelers from improper annoyances on either side.

The commissioners of the State Survey[2] reported to the legislature in 1879 that

> There is no American soil from which the Falls can be contemplated except at the pleasure of a private owner and under such conditions as he may choose to impose;

[1] Charles M. Dow, *The State Reservation at Niagara*, pp. 9-15.

[2] A survey by triangulation of the entire State of New York was undertaken, commencing in 1875, in the creation by the legislature of the New York State Survey. A board of commissioners of seven citizens was appointed. The legislature of 1879 resolved: "That the Commissioners of the State Survey are hereby directed to enquire, consider and report what, if any, measures it may be expedient for the State to adopt for carrying out the suggestions contained in the annual message of the Governor with respect to Niagara Falls."

none upon which the most outrageous caprices of taste may not be indulged or the most offensive interpolations forced upon the landscape.

Lord Dufferin, Governor-General of Canada, acting in accord with the Governor of the State of New York, called the attention of the government of Ontario to the suggestion of an International Park, and recommended co-operation with the State of New York to accomplish the purpose in view.

A public memorial[1] in behalf of the preservation of Niagara Falls, addressed to the Governor of New York and the Governor-General of Canada, in 1879, was signed by the highest officials and the leaders in literature, art, science, law and statesmanship in England and America. Rarely, indeed, has such a company of eminent men in different lands united in a common object. In this memorial occur the following sentences:

> Objects of great natural beauty and grandeur are among the most valuable gifts which Providence has bestowed upon our race. The contemplation of them elevates and informs the human understanding. They are instruments of education. They conduce to the order of society. They draw together all races and thus contribute to the union and peace of nations.

An increase of population of the village of Niagara Falls and the extension of the improvements for residences or industries along the bank of the river, above and below the falls, followed soon after the advent in 1877 of the Schoellkopfs as owners of the hydraulic canal and builders of houses and factories. The growth of this section of the village was naturally along or near the banks of the river, within sight of its rapids, its falls and its gorge. Many of the lots became points of vantage or of view for the land-owner or visitor, where the stranger was wont to become a victim and the tourist to abbreviate his visit.

These commercial aggressions impressed the increasingly numerous visitors to the falls with the urgency of preserving the natural beauties of the upper and lower rapids and the falls, beyond the power of private or selfish interests to diminish their grandeur, impair their attractions, or decrease the pleasure of their contemplation.

The grandeur and majesty of Niagara Falls are to be comprehended only by personal experience. As so eloquently expressed by James C. Carter, "it is the combined appeal to every sense and every faculty, exalting the soul into a higher sphere of contemplation which distinguishes this spot over all others. Niagara is an awful symbol of Infinite power—a vision of Infinite beauty—a shrine—a temple erected by the hand of the Almighty for all the children of men." Hence the movement to rid the spot of every touch of commercialism and as one of the recognized scenic wonders of the world, to set

[1] Annual Report of the State Reservation XIX, pp. 26–34.

it apart so that all nations and peoples of all languages might come together and behold the scene unmolested.

This idea soon became an organized public sentiment. Its expression in the press and legislature aroused the state administration to consider the public interests involved in the local situation. Plans were prepared for the purchase of the scenic property by the State of New York, to be held and maintained in perpetuity as a public park under the title of the Niagara reservation, free for the pleasure and education of the people.

James C. Carter indicated how large a part sentiment plays in the preservation of extraordinary natural scenery and how careful people have been for centuries and now are to protect such wonders as Niagara from profanation and exploitation. In alluding to the oracle at Delphi, Mr. Carter[1] said:

> The sentiments of men are oftentimes more powerful than their interests even, and history furnishes some interesting proofs of the depth of the feelings, closely akin to those of triumph of which we celebrate today, which connect the sentiment of reverence in man with great natural objects The superstition of early Greece asserted the existence at Delphi of a miraculous cleft in the earth, from which bursts forth a divine afflatus capable of inspiring the awful responses of Apollo, but this mere fable could scarcely have sufficed to render the spot the principal shrine of the favorite god. Situated in the most picturesque valley of Greece, at the foot of the lofty summit of Parnassus, it was the beauty and sublimity of the scene which enhanced the fame of the oracle It was the surrounding scenery exalting the imagination and kindling the religious emotions, which attracted the multitude of votaries and rendered the place the center of the Hellenic world. But the devout sentiments of the pilgrims were offended by the petty exactions of the neighboring seaport of Cirrha, and the fertile plain around the temple excited the cupidity of the neighboring husbandmen to make continual encroachments upon the sacred precincts of the god The evil was endured for a time, but in the end Greece arose in resentment at the profanation, and in a devastating conflict of ten years, fitly styled the "Sacred War," destroyed the offending town and choked up its harbor; swept from the Circassian plain all evidences of human ownership, and thus vindicated the insulted majesty of the god, and asserted the right of worshipers from every land to approach the great oracle unmolested.

LEGISLATION AND SELECTION OF SITE

In 1880 the State Survey Board recommended

> the extinguishment of the private titles to certain lands immediately adjacent to the Falls, which the State should acquire by purchase and hold in trust for the people forever.

In that year a bill was introduced in the legislature to authorize the selection of lands for a state reservation in the village of Niagara Falls. But action was delayed. To overcome such delay by united efforts to educate the people

[1] James C. Carter, of New York, in his oration at dedication of state reservation in 1885.

of the state regarding the conditions at Niagara Falls and the advantages of the proposed state reservation, an association was organized as "The Niagara Falls Association," under the presidency of Howard Potter of New York, with a membership of more than 300, including Charles Lanier and Edward D. Adams, the former of whom became treasurer of the association and both, later, directors of The Niagara Falls Power Company. The bill providing for selection of lands became a law April 30, 1883.

The commissioners appointed under this law selected a tract of 112 acres, in addition to 300 acres under water, comprising the entire area of 412 acres acquired for the state park, as shown by the following outline plan.

The reservation[1] was described by the following resolution:

RESOLVED, that in the judgment of this Board, it is desirable to select and locate as proper and necessary to be reserved for the purpose of preserving the scenery of the Falls of Niagara and of restoring the said scenery to its natural condition, the following lands situate in the village of Niagara and the county of Niagara, to wit: Goat Island, Bath Island, the Three Sisters, Port Island, Luna Island, Chapin Island, and the small islands adjacent to said islands in the Niagara River, and the bed of said river between said islands and the main land of the State of New York, and also, the bed of said river between Goat Island and the Canadian boundary, also a strip of land beginning near "Port Day" in said village, running along the shore of said river, to and including "Prospect Park" and the cliff and debris slope under the same . . . . and including also at the east end of said strip sufficient land not exceeding one acre for purpose convenient to said reservation, and also including all lands at the foot of said falls, and all lands in said river adjoining said islands and the other lands hereinbefore described.

APPRAISEMENT AND PURCHASE

The commissioners of appraisement, appointed under the supplemental Act of 1884, met at Niagara Falls on February 23, 1884, to view the premises and to take testimony respecting the ownership and value of lands that it was desired to acquire for the state reservation. The first consideration was given to Goat Island, the surrounding islands and a portion of Bath Island.

When under examination before the commissioners, Peter A. Porter stated that he appraised the island of 66.2 acres at $1,000,000, based upon the income to be derived therefrom, and exclusive of its value as a water-power site. Upon the completion of the appraisal, a report was made to the commissioner of a total valuation of all the lands to be acquired for the park, at $1,433,429, although the claim of the property owners amounted to about $4,000,000. This appraised valuation was confirmed by the Supreme Court and the awards made, upon this basis of value, for the purchase by the state.

A witness under examination expressed the opinion that Goat Island was the best location for hydraulic development of power, as it permitted a short

[1] See map, page 106.

inlet-canal near its middle, with side canals to wheel-pits discharging into the river on each side of the island.

The process of appraising the lands is described as follows:

Messrs. Luther R. Marsh, of New York, Matthew Hale of Albany, and Pascal P. Pratt, of Buffalo, were named by the court as Commissioners of Appraisement. Having taken their oath of office and viewed the premises they received testimony as to value. Their sessions for this purpose were held continuously through the month of July, 1884, and a voluminous mass of testimony received. In September they met to hear the final arguments of counsel, and on the 20th of that month made their report, which was filed with the testimony taken before them on September 22, 1884, in the office of the clerk of Niagara County.

In said report they awarded for the entire area of land to be taken to the respective owners and to all persons and corporations interested therein the total sum of $1,433,429.50.

Application on due notice was then made to the Supreme Court for the confirmation of this report, and on the 27th of October, 1884, an order was granted whereby the appraisers' report was in all things ratified and confirmed and the amounts awarded as compensation for the lands taken were ordered to be paid. This order of confirmation was filed and recorded in the office of the clerk of Niagara County on November 25, and in the office of the Secretary of State in Albany on November 26, 1884.

On the trial before the commissioners of appraisement a question of great importance arose as to the rights of the riparian owners to use the power afforded by the Niagara River for hydraulic purposes, and to receive compensation therefor. It was claimed by the proprietors of the islands and of riparian lots that they owned the bed of Niagara River, and independently of this, that they had a right to use, without stint, the power afforded by the rapids and the falls for hydraulic purposes; and they claimed that they should be compensated for the value of this vast water-power, even where it had not been reduced to use. Upon this basis they were prepared to present claims aggregating twenty or thirty millions of dollars. After full argument and careful consideration, the commissioners of appraisement rejected all such claims, except where the water-power had been actually reduced to use and used for a period long enough to create a prescriptive right They hold (1) that Niagara River is a public stream, and its bed and waters belong to the state; (2) that as against the state private riparian owners have no right to encroach on its bed to divert its waters, or to subject them to the burden of manufacturing uses, unless they have acquired such right by grant from the state or by prescription. As two of the commissioners of appraisement first above mentioned are distinguished lawyers, their decision on these points is entitled to great weight.

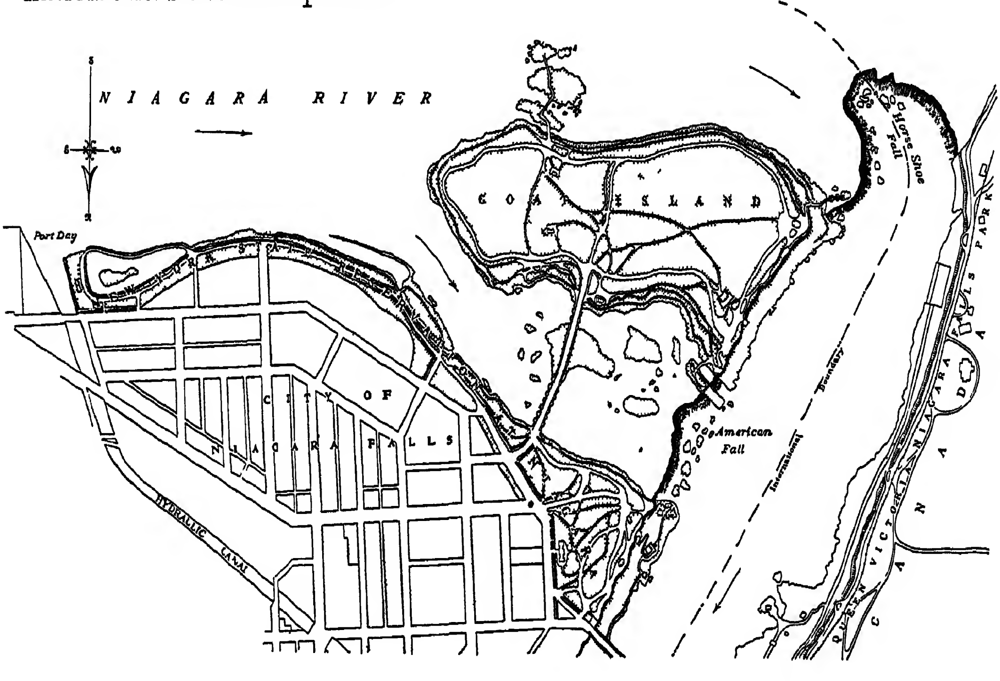
After the exclusion of such claims for the value of unused water-power, the claims of the owners of the property amounted to about four million dollars. The aggregate awards, as already stated, are but little more than one third of this sum.

An act to acquire the lands selected for the proposed reservation, and an "Act to provide for the maintenance and management of the State Reservation at Niagara" became laws in 1885.

PUBLIC INTEREST IN THE RESERVATION AND POWER

On July 15, 1885, the lands were accepted by Governor Hill on behalf of the state, and the reservation was formally opened to the public, under the control and supervision of the Commissioners of the State Reservation at Niagara, as defined by the laws of 1883.

About 75,000 enthusiasts gathered at these ceremonies in Prospect Park, at which numerous guests from Canada besides prominent officers of the nation and state were present.[1]



State Reservation at Niagara

From Dow's "Anthropology and Bibliography of Niagara Falls"

Following the dedication of the park, the demolition of about one hundred and fifty buildings, that debased the scenic beauties of the falls and their immediate surroundings, proceeded slowly by reason of inadequate financial resources available.

The revelations of impressive scenery hidden by commercial obstructions for more than one generation, created surprise and admiration, while the people acclaimed the legislative action that made the restoration possible and permanent.

[1] There were 2741 cars in the excursion trains in the season of 1887 that brought 166,000 visitors to Niagara Falls. The visitors crossing the bridge to Goat Island, in the fiscal year to June 30, 1924, amounted to 2,179,710 and for the year 1924–1925 to 2,445,772. The parking of automobiles and providing for the necessities of the family visitors in their travelling bungalows, have become a present problem in the administration of the daily affairs of the Niagara Reservation.

Natural conditions having been finally restored, facilities were afforded for easy access to vantage points for rest and the quiet enjoyment of sound, form and color and the many expressions of creative power that are recognized in the grandeur, sublimity and wonders of Niagara Falls. And what a transformation was brought about and with what enlightened interest visitors began to view the site!

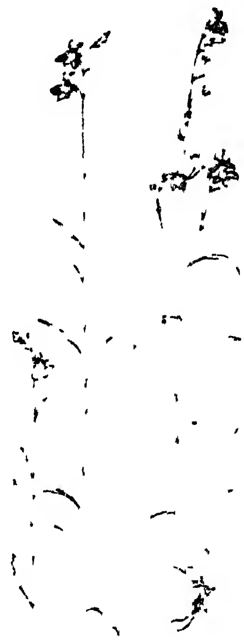
Here people of diverse tastes now meet and pursue their various interests without interruption by so-called guides or conflict with local speculators.

The botanist explores the island, examines the lists of the flora and seeks the Lobelia kalmii and the Hypericum kalmianum associated in name with Kalm, the Swedish botanist, who visited the falls in 1750.

HYPERICUM KALMIANUM[1]

ST. JOHN'S WORT

Grows Naturally from Ontario and Western New York to Michigan and Wisconsin



LOBELIA KALMII

KALM'S LOBELIA

Grows from Nova Scotia to Manitoba and Southward to Massachusetts New Jersey, Ohio and Michigan

[1] An example of the Lobelia was found on Goat Island on September 7, 1926, by Miss Mary E. Eaton of the New York Botanical Gardens, who reproduced it in color. A search by her with the assistance of the local superintendent failed to discover any examples of the Hypericum. Apparently it had died out, as the superintendent had not seen any specimens for several years. Dr. John A. Torrey obtained a specimen of this plant either on Goat Island or the table rock at Niagara in 1842. This was published as a colored illustration in "The Flora of New York," 1842. Miss Eaton made a copy of this illustration in water-color, so that these two plants discovered and named for Kalm will be preserved as represented by Miss Eaton in the Niagara Museum.

The geologist is interested in the geology, rock stratification, fossils, evidences of glacial action, and the recession of the falls.

The historian inquires about the aborigines, the Neuter Nation, the French discoverers, the titles to the land and the water, the portage trails and the arrow-head quarry.

The lover of nature is concerned lest the beauty and grandeur be lost by the diversion of water or through the self-destruction of the cataract.

The engineer inquires as to the source, the quantity and regularity of flow and proposes means for controlling the water and developing and distributing its power for myriad uses.

The far-seeing citizen and the statesman, concerned with the conservation of our natural resources, deplore the waste of energy and wonder why so little is being used. They ponder as to the rising price of coal and they estimate the true economic value of power derived from exhaustible mineral, precious for producing heat, compared with that from the inexhaustible and ever-renewing supply of water.

POWER

The establishment of the state reservation naturally placed restrictions upon power development and greatly increased the difficulties and expenses involved.

Because of the purchase of the shore of the river by the state, new power developments must be made outside of the reservation. This established the western limitation to all projects for the diversion of water from the river at a point approximately 1 mile above the falls and its return to the river, a half mile below the falls, thus greatly adding to the expenses and other difficulties of power developments. These very difficulties, however, hastened the coming of the new order in the practical utilization of the falls.

As the natural beauties became enhanced through the appropriate setting provided by the park system, it became apparent to those who most ardently desired to put the waters of Niagara to work, as well as to others, that no jarring structures or other desecrations would be tolerated within or immediately beyond the reservation. Thus the architectural features of the two power-houses erected above the falls were designed to give an air of dignity as well as stability to the place.

Strength is also embodied in the structures to withstand the elements without and to control the forces within.

The high banks below the falls no longer advertise the improvident use, as in several early instances, of only one-third of the available power; unsightly structures have been replaced by rugged strongholds of power that, like the power-houses above the reservation, inspire confidence in the forethought of

the management that has built for permanency of occupation, regularity of production, continuity of service and efficiency of operation.

Here is the source of heat, light and power that is rendering a useful and important service in the industrial and domestic life of millions of people in the State of New York, and is contributing to electro-chemical products which are indispensable to the nation.

Niagara has been developed to perform the double service of ministering to material prosperity and to spiritual well-being.

VISITORS TO GOAT ISLAND

The monthly visitors to Goat Island during the two years from September 1, 1923–1924 and 1924–1925 are officially reported as follows:

	1923–1924	*1924–1925*
October	100,750	135,935
November	61,378	59,508
December	39,856	24,769
January	26,246	52,057
February	34,713	56,452
March	51,615	60,800
April	101,326	151,708
May	161,492	233,120
June	313,636	370,456
July	475,323	485,088
August	586,303	505,331
September	227,072	310,548
	2,179,710	2,445,772

In spite of the fact that the number of tourists who visited Niagara Falls during the summer of 1926 decreased at least 30 per cent, the stream of visitors to the Niagara Falls power-plant knew no diminution. On August 15, 1926, alone, 3264 tourists viewed the "great triumvirate of power" in Station 3-C, belonging to The Niagara Falls Power Company, taxing the maximum capacity of the company's facilities to receive its guests, causing a congestion in traffic by elevator and stairway at times.

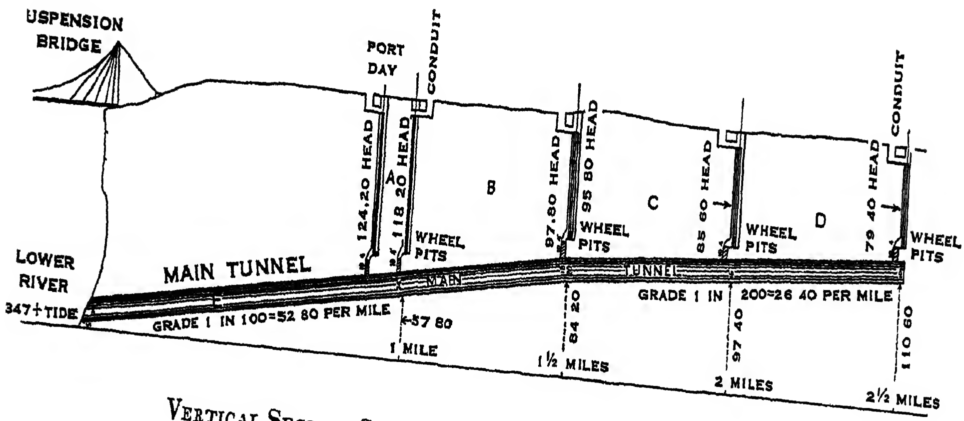
EVOLUTION OF
THE NIAGARA FALLS POWER COMPANY

THE EVERSHED SCHEME

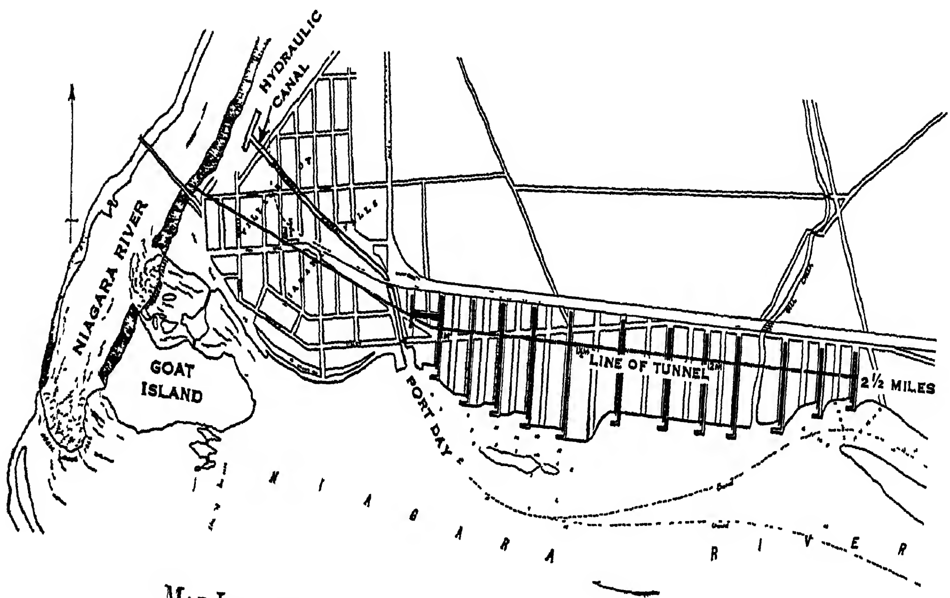
NIAGARA RIVER HYDRAULIC TUNNEL, POWER AND SEWER COMPANY, THE BEGINNING OF THE ENTERPRISE WHICH DEVELOPED INTO THE NIAGARA FALLS POWER COMPANY, 1886

Chapter VII

The Evershed Scheme[1] Indicating Elevation of the Tunnel and Plan of the Canals



Vertical Section Showing Several of the Wheel-pits



Map Indicating Location and Scope of Evershed Plan

Twelve canals supply water to 238 wheels distributed over an extended area which discharge through a common tunnel system

[1] See Chapter XVII, Volume II, for details of the Evershed proposals and of its modification by The Cataract Construction Company.

THE EVERSHED SCHEME

PROMOTED BY THE NIAGARA RIVER HYDRAULIC TUNNEL, POWER AND SEWER COMPANY, THAT UNDER OTHER OWNERS USING DIFFERENT METHODS BECAME THE NIAGARA FALLS POWER COMPANY WHICH CONTRACTED FOR THE DESIGN, CONSTRUCTION AND FINANCE OF ITS ENTERPRISE WITH THE CATARACT CONSTRUCTION COMPANY

CHAPTER VII

ORIGINAL EVERSHED SCHEME

WE come now to the inception of the project destined to develop into the first successful application of Niagara power on a scale commensurate with the magnitude of the falls and with the demands of modern industry. It necessitated methods then practically unknown and apparatus not yet invented but which were soon developed and here first used in creating a gigantic universal power system, for operating industries of the old type and making possible others, new in kind and in products. The following account has been derived in part from some of those who participated in its early promotion.

On February 3, 1886, there appeared in the *Lockport Union*, a newspaper published in the city of Lockport, Niagara County, a letter to the editor from Thomas Evershed, of Rochester, a division engineer of the Erie Canal. The letter was head-lined "Engineer Evershed's Water-Power Scheme." In his letter Mr. Evershed discussed a proposition, which had appeared in the same newspaper, by Alexander Holley, a hydraulic engineer of Lockport, which involved the construction of a surface canal from the Niagara River about 10 miles above its Great Falls, at or near North Tonawanda to Lockport, a distance of nearly 15 miles; the development there, upon the Niagara escarpment, of a great hydraulic power and the discharge of the tail-race waters through the "Eighteen Mile Creek" into Lake Ontario, a total distance from river to lake of about 25 miles. After explaining why the project was impracticable, Mr. Evershed stated:

> If the people of Niagara County wish to indulge in a scheme for a magnificent water-power, let me point out one.

He then outlined a plan for power development at Niagara Falls which he described as follows:

> Beginning at a point in the gorge below Niagara Falls just north of the state reservation and the upper Suspension Bridge, and about twelve feet above the surface of the water. run a tunnel so as to strike the river above the mouth of the hydraulic canal, a

With wheel-pits sunk in the rock this water could be used with turbine wheels under a head of eighty to one hundred feet as is now done below the high falls at Rochester. A hole or holes drilled from the bottom of these wheel-pits into the tunnel below, will take off the water so used.

The wheels could be placed every twenty-five feet apart if necessary, and the power cabled off to any point desired, running any number of mills and factories of any size, from the making of toothpicks to a Krupp's foundry.

The cost of doing this can be calculated, say the tunnel is sixteen feet square or equal thereto, in round numbers 1,000,000 yards at $9.00 a yard, $9,000,000, say $10,000,000.

This scheme, it will be observed, was a reversal of previous designs. In the earlier projects mills on the edge of the cliff below the falls received their water through an open canal and utilized a portion of the fall at the cliff, on which buildings were erected for its use. The hydraulic development proposed by Mr. Evershed was to be constructed mainly as a tunnel and located between the lower and the upper river about 1 mile or more above the Great Falls. There was no departure from the familiar custom of a mill over a wheel-pit. It was hoped that by the arrangement proposed, the old difficulty at Niagara Falls "that there has not been land enough to use the water-power,"[1] might be obviated. The long tunnel was intended to facilitate the location of the industrial district above the falls and beyond the limits of the state reservation to a site where ample facilities might be provided by land, dockage, streets and railroads to accommodate 238 mills of 500 horse-power each, a total of 119,000 horse-power.

Mr. Evershed's letter immediately attracted the attention of Myron H. Kinsley, of Niagara Falls, who was then the superintendent of the Oneida Community, Limited, manufacturers of metal wares and one of the early users of water-power from the canal of the Schoellkopf company, The Niagara Falls Hydraulic Power and Manufacturing Company. Mr. Kinsley became greatly interested in the project and brought it to the attention of Charles B. Gaskill, another local manufacturer, and one of the first users of power from the hydraulic canal. Colonel Gaskill quickly comprehended the possibilities of the Evershed plan and the two manufacturers consulted Henry S. Ware, of Niagara Falls, who was then engaged in the contracting business.

After conference they consulted Thomas V. Welch, a prominent citizen who had been a member of the state legislature and had taken the leading part in securing the passage of the legislation which resulted in establishing the New York State Reservation at Niagara, of which, at this time, he was the superintendent.

[1] Testimony of Stephen M. Allen in 1884 before the commissioners of the state reservation.

It was also deemed wise to bring the matter to the attention of William Caryl Ely, a lawyer at Niagara, who, with Mr. Welch,[1] had been a member for several years of the State Assembly, and who had recently come to the falls to practise his profession. He had been a resident of an interior county and prominent in the Democratic Party and its candidate the previous year for Speaker of the Assembly. He likewise had participated in the final stages of the effort to make "Niagara free," and was a man of wide acquaintance and fully cognizant of the difficulties that might be expected to be encountered in any such matter requiring legislative action.

These five men in February, 1886, met at the office of the superintendent of the state reservation, on Bath Island, and discussed the practicability of Mr. Evershed's plan and its possibilities.

Personal familiarity with the local conditions at Niagara Falls and the history of several unsuccessful efforts that had been made for the utilization of the falls, prompted the promoters of the project of 1886 to seek facilities and powers of the state authority under special legislation or charter that could not then be obtained under the general laws prevailing at that time.

The franchise requirements in aid of new forms of industrial development had not at that period been publicly recognized as of sufficient importance to be provided for in the general laws of the state, to which incorporators of industrial projects had recourse for capitalization and operating powers.

Nevertheless, projects of general public interest and novelty and of sufficient promise in prospective expenditure to attract the support of citizens of wealth and influence were at that period encouraged by special legislation to meet what were thought to be their special necessities. The granting of such special charters had then begun to attract public criticism as a bestowal of valuable rights without adequate compensation or the reservation of control by the state.

PROCURING THE CHARTER

The determination was reached by the parties above named, to proceed with the enterprise to procure a charter by special act of the legislature, and to Mr. Ely was delegated the preparation of a bill for that purpose.

It was also decided to associate as incorporators Mr. Evershed, the author of the scheme, James Fraser Gluck, an attorney at Buffalo, and Michael Ryan, the business partner of Mr. Welch, at Niagara.

The bill having been prepared by Mr. Ely and approved by Mr. Gluck, was taken to Albany by Messrs. Welch and Ely and was submitted to Peter A. Porter (son of Gen. Peter B. Porter), then member of the Assembly

[1] See *How Niagara Was Made Free*, Thomas V. Welch, 1885.

from the Niagara Falls district. After carefully considering the matter, Mr. Porter approved the proposed bill and introduced it in the Assembly.

Upon Mr. Ely then devolved the burden of managing the bill, which, in view of the current opposition to special legislation, provoked much discussion and exhibited at various times the undeniable symptoms that usually denote the danger of what might be termed "legislative asphyxiation." The bill probably would have failed had it not been for the aid of William F. Sheehan, of Buffalo, then beginning to loom large against the political horizon. He was the Democratic leader and at several critical moments actually assumed personal charge of the measure and made the motions necessary to secure its advancement. He was also powerful in its behalf in the Senate. The bill finally passed both houses and received the consideration, and finally the approval of the governor on the 31st day of March, becoming Chapter 83 of the laws of 1886, thus incorporating the Niagara River Hydraulic Tunnel, Power and Sewer Company of Niagara Falls, New York, known as the tunnel company.

The corporate name, which seemed to some persons to be somewhat extraordinary and possibly to some amusing, had been chosen with great care and served the useful purpose of imparting to the legislation a public aspect, which was to be serviceable during all the time in which the incorporators were engaged in procuring the charter and the company in procuring the public and private grants of the privileges, easements and titles to lands necessary for its purposes.

Meanwhile, a bill had been prepared under the auspices of the Chamber of Commerce of the city of Lockport, to incorporate a power and water supply company on the lines of the Holley plan heretofore referred to. That charter became a law before the charter of the tunnel company was passed. It was not opposed by the Niagara Falls interests, for by agreement each party rendered assistance to the other.

Notwithstanding the growth of sentiment against such special laws and the recognition by the governor and the state legislators of this attitude of the public, they were not slow to appreciate the force of the argument of W. Caryl Ely, of Niagara, that the greatest available natural power of the world was carrying seaward or was wasting unutilized and without cessation, the wealth of an empire, and that the company attempting to harness even a small part of such forces required and was entitled to the encouragement of special authorities and powers, not provided under the general laws of the State of New York.

When signing the act incorporating the tunnel company, the governor is said to have remarked that he would have preferred the charter to have been issued under the general laws, but he recognized the impracticability, and signed this special law, although the ink was scarcely dry upon a message he had sent to the legislature advising against such special enactments.

The fact that the original charter of March 31, 1886, was amended by acts of special legislation on five separate occasions, of which three were each in consecutive years of the company's most rapid growth and greatest expenditures, is an evidence that its pioneer work was recognized by the people of the state and encouraged by its legislators.

The special acts are described as follows:

ORIGINAL CHARTER

CHAPTER 83, MARCH 31, 1886

Capital stock limited to $3,000,000. Corporate existence fifty years.

AMENDMENTS

CHAPTER 489, MAY 29, 1886

May issue full paid shares in payment for land and other property necessary for the business.

CHAPTER 109, APRIL 5, 1889

Additional tunnels, sewers or conduits authorized. Power given to deal in lands and to take and use water from Niagara River. Unpaid subscriptions to shares may be cancelled within one year. Bonds authorized secured by mortgage.

CHAPTER 253, APRIL 23, 1891

May acquire and hold shares in certain other companies and issue shares therefor and acquire title to property under condemnation law of the state. Increase capital stock to $10,000,000.

CHAPTER 513, MAY 12, 1892

Company made subject to certain provisions of the stock corporation law of the state. Rights to use water within prescribed limits made subject to supply of water and electricity for light and power, free of charges, to the State Niagara Reservation. Right to take water from Niagara River restricted to no "more water than shall be sufficient to produce two hundred thousand effective horse-power."

CHAPTER 477, APRIL 25, 1893

Stockholders' liability to creditors made subject to provisions of stock corporation law of the state. Company empowered to furnish waters of Niagara River not exceeding amount heretofore expressly authorized (200,000 effective horse-power), or any power, heat or light developed therefrom in any civil division of the state.

The pioneer or experimental character of the venture and the developments of its program of construction may be traced in the successive enactments of the state legislature, primarily constructive and as requested by the company, and later restrictive by the state for the protection of its citizens as the possibilities of the extent of the power distribution system proposed and its adoption were understood and appreciated in its possible effect upon the beauty of the Great Falls as nature fashioned them.

Although the company was authorized by its amended charter to acquire title to land in the manner specified by the condemnation law of this state, no use of this power has as yet been made by the company in its many negotiations for use or ownership of real property. The state, however, used its power of condemnation in procuring some of the property that was included in the Niagara State Reservation, reserved for the recreation of its citizens and visitors.

ORGANIZATION

The Niagara River Hydraulic Tunnel, Power and Sewer Company was organized at Niagara Falls in June, 1886, and commenced its operations under the leadership of Charles B. Gaskill and the local associates as officials, namely:

Officers

President	Charles B Gaskill
1st Vice-president	Henry S. Ware
2nd Vice-president	Michael Ryan
Treasurer	Francis R. Delano
Secretary	Myron H. Kinsley
Attorneys	W. Caryl Ely, Niagara Falls J. Fraser Gluck, Buffalo
Engineer	Thomas Evershed, Rochester

The capital stock book was opened and the sum of $200,000 was subscribed as follows:

	Shares
Francis R. Delano	167
W. Caryl Ely	167
Thomas Evershed	167
Benjamin Flagler	167
Charles B. Gaskill	166
James Fraser Gluck	167
Myron H. Kinsley	166
A. Augustus Porter	166
Peter A. Porter	167
Michael Ryan	166
Henry S. Ware	167
Thomas V. Welch	167
$200,000 par value of	2000

PROSPECTUS

In the meantime, the plans of the company were being matured; a prospectus was in preparation, and preliminary conferences and correspondence were being carried on with engineers, financiers and manufacturers by those connected with the enterprise. In August, 1886, the printed prospectus[1] made its appearance. At a meeting held August 25, 1886, the president reported that he had placed a book for stock subscription at the Manufacturers and Traders' Bank at Buffalo, subject to a commission of five per cent on all subscriptions obtained, and that the president of the bank had evinced a very great interest from the beginning in the plans of the company. Thomas V. Welch and Benjamin Flagler were appointed a committee to arrange for opening stock subscription books at the offices of bankers in New York and Boston. The effort was to obtain subscriptions in New York for $500,000, in Boston for $500,000, in Buffalo for $200,000, and in Niagara Falls for $200,000, a total of $1,400,000, and the secretary was directed to ascertain what arrangements, if any, could be made to obtain subscriptions in Minneapolis, Chicago and London.

Charles B. Gaskill, the president of the company, communicated with many manufacturers of the country and stimulated by him and his associates, Mr. Evershed, who had been made the engineer of the company, communicated with such engineers as James B. Francis, of Lowell, Clemens Herschel, then of Holyoke, and J. T. Fanning, of Minneapolis, all hydraulic engineers of high reputation who had been successful in the development of the largest water-powers then in use in this country. Mr. Evershed's report, presented to the board of trustees at its meeting July 1, 1886, showed that he had devoted a great deal of labor to the preparation of the plans, and that they had been submitted by him to Elnathan Sweet, state engineer and surveyor, who on July 19, had approved them in a letter to President Gaskill as shown in the prospectus of the company. On September 9, the board of trustees of the village of Niagara Falls passed resolutions formally consenting to the construction, operation and maintenance of the tunnel underneath the village.

That it would be difficult to secure the necessary money by stock subscription was apparent to all of the incorporators. Nevertheless, it was determined to endeavor to obtain the capital in this manner if possible. It would at least serve a useful purpose, it was claimed, in giving to the enterprise a great deal of desirable publicity.

[1] *Water Power at Niagara Falls to be Successfully Utilized.* Company prospectus, with maps, 1886. First edition.

*FRANCIS R. DELANO

FRANK A. DUDLEY

HENRY DURK

*W. CARYL ELY

OFFICERS
AND DIRECTORS
OF THE
"GASKILL COMPANY"
THE
NIAGARA RIVER
HYDRAULIC TUNNEL,
POWER AND SEWER
COMPANY
OF
1886

*THOMAS EVERSHED

Negotiations were opened with the leading men of Buffalo, as well as those at Niagara Falls, but without success. The subject was also introduced among various bankers and others of New York City and Boston, all of whom were disinclined to become financially interested in the stock of the company.

The prospectus of 1886 contained the following paragraph under the subject title of

POWER FROM NIAGARA FALLS BY ELECTRICITY

It is conceded by leading practical electricians that it would be entirely practicable now to light the city of Buffalo (distance 20 miles) with power furnished by Niagara Falls, and the opinion is rife among scientific men that ways will be found in the near future for transmitting this power to much greater distances and for using it in many new ways. Should this be done, the unlocking of this great natural store-house of power,

* Deceased

*BENJAMIN FLAGLER

*JAMES FRASER GLUCK

*GEN. DANIEL W. FLAGLER

*MYRON H. KINSLEY

OFFICERS
AND DIRECTORS
OF THE
"GASKILL COMPANY"
THE
NIAGARA RIVER
HYDRAULIC TUNNEL,
POWER AND SEWER
COMPANY
OF
1886

*LAUREN W. PETTEBONE

which is proposed in this prospectus, will bear an importance not exceeded by any private or public work in the State. It cannot fail to interest every one.

An application has already been received from a manufacturer in Birmingham, England, for an opportunity to test his apparatus for conveying power by means of compressed air.

President Gaskill had already taken up the matter of possible electrical development with Gardiner C. Sims, of Armington & Sims Engine Company, Providence, Rhode Island, who was born in Niagara Falls and whose mother and brother were at the time still residing there in their old home, to which Mr. Sims occasionally returned. Mr. Sims was a co-worker with Thomas A. Edison, and in the engine works at Providence constructed the engines

* Deceased

ALEXANDER J. PORTER

*PETER A. PORTER

*MICHAEL RYAN

*HENRY S. WARE

OFFICERS
AND DIRECTORS
OF THE
"GASKILL COMPANY"
THE
NIAGARA RIVER
HYDRAULIC TUNNEL,
POWER AND SEWER
COMPANY
OF
1886

*THOMAS V. WELCH

that were used in the Edison experiments and developments. As early as November, 1886, Mr. Sims informed Colonel Gaskill that Mr. Edison had investigated the possibility of transmitting electrical power from Niagara Falls to the city of Buffalo, and had gone as far as to make estimates of costs and efficiency.

LONDON NEGOTIATIONS

Messrs. Welch and Ely, who during their legislative experience had become well acquainted with Francis Lynde Stetson, a prominent lawyer of New York City, determined to talk the matter over with him, and Mr. Welch went to see him. Mr. Stetson manifested a great deal of interest in the matter in a preliminary way and encouraged Mr. Welch to feel that he would give it

* Deceased

careful investigation. Nothing definite resulting from this, President Gaskill opened negotiations with Raymond S. Perrin, of New York, who stated that he had business relations with T. Gilbert Bullock, of London, who was the representative of an English syndicate, and requested that he be given an opportunity to enlist the interest of Mr. Bullock and his friends. Authority being given Mr. Perrin, he took the matter up with energy and in December appeared at a meeting of the tunnel company at Niagara Falls and presented definite proposals for a contract of option to purchase all the rights and property of the company on behalf of Mr. Bullock, as the representative of an English syndicate. A resolution was adopted authorizing President Gaskill to make a contract to sell Mr. Perrin, or his assigns, all the company's property rights, privileges and franchises for $650,000, payable in installments, at the office of the Farmers Loan and Trust Company of New York, on or before the following dates:

February 1, 1887	$100,000		
April 1, 1887	100,000		
June 1, 1887	178,000		
		$378,000	
Balance in contracts for land to be assumed		272,000	
Total			$650,000

Contingent upon the faithful performance of the contract for sale, a contract was authorized granting to Raymond S. Perrin for ten years the right to lease 125 mill-sites to be selected by him, of an average size of 100 by 200 feet, with 500 horse-power available for use thereon, for the annual rental of $5 per horse-power, payable from the time the mills were put in operation.

Authority was also voted in favor of a contract with Raymond S. Perrin for the construction of the main and cross tunnels, conduits, shafts, raceways, bulkheads, masonry and appurtenances.

The resignations of officers and trustees and the surrender of all rights of incorporators, effective upon performance of contract of sale by Mr. Perrin, were also agreed upon, prepared and signed.

About the first of December, the contracts with Mr. Perrin were signed and deposited in escrow with the Farmers Loan and Trust Company of New York.

The annual report of the company, published as required by the state laws, January 18, 1887, in daily papers, declared its existing debts to be $700, and that its capital stock was $200,000, all subscribed, but of which no portion had been paid in. This report could not have been other than detrimental to the pending financial negotiations in London.

At this stage the matter had become intensely interesting. The advices from England were frequent and showed that the Bullock syndicate had put up a considerable amount of money for the development of its plans, which resulted in the incorporation in London, of the Niagara Falls Hydraulic Tunnel, Power and Sewer Company, Limited, with an authorized capital stock of £1,000,000 and with a very distinguished board of directors. It was stated at Niagara that the English syndicate had provided £20,000 for expenses so far as might be found necessary by its representatives in their investigation of the project.

The London prospectus, printed, but not issued, quoted the reports of the American engineers, Elnathan Sweet, New York State Surveyor, and Thomas Evershed, division engineer, New York State Canals. The reports also of English engineers were quoted as follows:

May 31, 1887 — Jabez Church, Past-president, Society of Engineers, London

I am of opinion that the proposed works could without doubt be successfully carried out.

June 17, 1887 — G. N. Abernethy, Member, Institution of Civil Engineers

I can see nothing in this scheme which in my opinion presents any extraordinary difficulty in construction. The scheme taken as a whole seems ably designed and the details well considered, the power being also well distributed and economically arranged.

November 15, 1887 — Hazzard and Tyrrell, Members, Institution of Civil Engineers

The scheme as laid out by Mr. Evershed is simple and well designed and would no doubt realize, as motive power, the results expected from it To assure continuity of operation these engineers strongly recommend that all the tunnels should be lined throughout in the most substantial and permanent manner. This would increase the estimated costs to $600,000.

It is noteworthy that none of the reports of the English engineers mention recent visits to Niagara Falls as the basis of their information.

The prospectus also contained the following:

Sir William Siemens pointed out, according to the London *Standard* of December, 1886, that if all the coal produced by all the mines in the world were used for raising steam and applied in the most economical manner, it would not create a force equal to the Falls of Niagara. What however principally struck Sir W. Siemens was the power of the Falls to drive dynamos, by which power could be conveyed by electricity to a distance, and the electric light supplied to all the towns of the State of New York.

When the original negotiations with Mr. Bullock assumed form, they began to move more rapidly, and it was arranged that cablegrams should be

sent to the Canadian side of the river and then delivered to the company on the American side by messenger from the telegraph office on the Canadian side. This was in accordance with the confidential conduct of all these financial negotiations, which were attended with great secrecy. About the middle of January, 1887, a cablegram arrived announcing that the English syndicate was a success and that the payment of the first $100,000 would be made on February 1, 1887, the due-day therefor. Messrs. Ely, Gaskill, Kinsley and Welch met at one of their homes and indulged in mutual congratulations. One may not even imagine their chagrin when they discovered that the cablegram had been sent by mistake to the telegraph office of the New York Central Railroad upon the American side. The New York Central agent, immediately sensing its importance, sought out a friend, who possessed both courage and capital, and together they had ridden the surrounding territory and secured options upon a great deal of land, so that when the quartet of promoters attempted to secure land for the company and themselves, "the cat was out of the bag" and the prices of all lands anywhere in the vicinity of Niagara Falls had advanced greatly, never to come down to the former value. By reason of what he had done the agent lost his position, but he immediately opened up a successful real estate business and became independent of railroad employment. His partner in the land option campaign is said eventually to have realized what to him was a fortune by the operation As a result, the tunnel company and its discreet promoters paid comparatively high prices for lands purchased thereafter.

FINANCIAL DISAPPOINTMENTS

Before the arrival of the date set for the first $100,000 payment, there came a hitch in the proceedings; the payment was not made and the time was extended. On March 24th, at a meeting of the company, President Gaskill stated that George Bliss, a lawyer of New York, had been retained on behalf of some persons interested in the English tunnel company to make an examination of all contracts and other actions taken by the Niagara River Hydraulic Tunnel, Power and Sewer Company, and had applied through attorney William B. Rankine, of New York, for additional papers. This is the first recorded mention of Mr. Rankine's name in connection with the enterprise.

Mr. Rankine stated that Mr. Bliss was making a critical examination of the papers on deposit with the Farmers Loan and Trust Company on behalf of the London and Westminster Bank, the bankers of the English company.

The report of Mr. Bliss made an unfavorable impression in London and caused the syndicate to withdraw from what was considered a "risky and

unwise investment." Thereupon the syndicate surrendered its optional contract, provided for its expenditures, about $20,000 it was reported, and dissolved.

RESUMPTION OF FINANCIAL NEGOTIATIONS AT HOME

The five original promoters of the enterprise were greatly disappointed at the failure of the London negotiations. At the commencement of their efforts they had high expectations of a successful project, creditable to their local position, advantageous to the community, and profitable to all parties interested therein. Now they were in the slough of despondency. But under the patient and persistent leadership of Charles B. Gaskill they determined to continue their efforts to finance the project, even though they might be obliged to abandon all expectations of personal profit as the originators of the project, in order to make a success of the undertaking.

An assessment of $150 each was voted by the ten trustees present at a meeting held January 25, 1888, to meet a note at the bank and other current expenses.

About this time A. Augustus Porter died, and his son, Alexander J. Porter, returned to the falls to live and look after the interests of his father's estate. He became the secretary of the company in place of George N. Miller, who resigned after having served well in that capacity from the inception of the company and without compensation. Alexander J. Porter was elected a trustee, June 2, 1888.

After the failure of negotiations with the English syndicate, an effort was made to interest the financial group in control of the New York Central Railroad through their counsel, Daniel H. McMillan, of Buffalo, to whom options were given on two separate occasions. Here again was disappointment, and loss of time and money.

As it was believed that the familiarity of the great public with the name Niagara and what it represented in water-power going to waste, might be utilized to secure the necessary capital, books of subscription to the capital stock of the company were again opened, and the plans were exhibited in various cities, but this method was not successful.

Prior to the English negotiations of 1886–1887, William B. Rankine, whose family resided in the western part of the state, and who was familiar with affairs at Niagara Falls, presented the subject of the improvement of the Niagara water-power to Francis Lynde Stetson, with whom he had been associated in the office of the Corporation Counsel of that city.

The passage of the Act of 1886, authorizing the Niagara River Hydraulic Tunnel, Power and Sewer Company, by special charter, to utilize the power of Niagara Falls, attracted much attention. The efforts made to finance the

company in 1887 in the English as well as the American money markets were well understood in financial and engineering circles, and their failures deplored, particularly in the western part of the State of New York, where great advantages were expected from the utilization of the falls, in increase in values and in the population that would be attracted to that section by the prospect of inexhaustible and never-failing power, at prices below those prevailing for power as then produced from coal.

The opinion became current in Niagara and Buffalo that the Evershed plans for the power development were not adapted to the natural conditions of the locality, especially from the point of view of the financier, who could not be assured of current income upon an investment of large and doubtful amount and unknown risk that had been previously declined by numerous engineers and practical men who were familiar with the local surroundings.

It was stated that the original promoters of the tunnel company, after five years of strenuous and loyal co-operation, expressed the opinion, in explanation of the causes of their lack of success, that the project dealt with hydraulic forces far greater than man had ever before attempted to control. Men of experience and capital, it is said, warned investors that the project was visionary and unsafe.

Although local pride prompted the exhaustion of all possible efforts to promote the enterprise, the results were discouraging. The population and property of that community were comparatively small, and its business activities were conservative and mostly inherited.

The promoters of the enterprise were not capitalists. They were devoted admirers of the falls, which they considered a public asset of great value. They were confident believers that the practical people of the nation would eventually utilize the great force that was hourly wasted. They were loyal to the interests of their neighbors. They cherished hopes of accomplishment and fortune, but through the anxieties of prolonged and unsuccessful negotiations at home and abroad, they had acquired experience and were prepared, if necessary, to surrender expectation of profit if they might achieve their purpose to bring prosperity to the community in which they lived.

It was true that local men, who should best understand the value of the opportunities, had examined the merits of the enterprise as presented and declined to invest or recommend. But the promoters of Niagara Falls had faith that somehow—but they could not then conceive in what manner—other people's money and experience might accomplish what was so greatly desired as a stimulus to local prosperity. Engineering and financial circles at home and abroad had considered the project and declined. The name Niagara

had failed to conjure capital for its control, but the falls still remained as a delight and wonder, while its observers pondered its problems of nature and entertained dreams of science applied.

EARLY NEGOTIATIONS WITH MR. STETSON

It was under these conditions that the Niagara promoters again sought to interest Francis Lynde Stetson, of New York, in their project. Mr. Rankine resumed his negotiations of the previous year on behalf of the tunnel company with Mr. Stetson, who gave attention to the subject from time to time during the following year, and on June 2, 1888, acquired an option to purchase the capital stock of the company.

Further investigations followed during the year and the option was surrendered in December, 1888.

It was then determined to attempt to place an issue of the company's bonds. Messrs. W. Caryl Ely, Henry S. Ware and James Fraser Gluck were appointed a committee to consider the plan therefor. They reported at a meeting held December 15, 1888, in favor of an issue of $2,500,000 bonds bearing interest at five per cent per annum and maturing in 20 years. The committee also recommended that "proposals for construction and transmission by electricity be obtained."

President Gaskill reported to this meeting the names of persons from whom he had secured offers to take power to an aggregate of 12,900 horsepower for the gross amount of $124,500 annually, and that in addition, a company would be formed at Tonawanda to take power which would yield $5000 per annum.

At this meeting Colonel Gaskill presented a draft of a revised prospectus and a report from Mr. Evershed, the engineer of the company, dated December, 1888, giving details of estimates of dimensions, locations and costs of tunnels and cross tunnels, and necessary lands and the location thereof. A committee was authorized to prepare and present at the next meeting of the trustees, a proof of the new prospectus. This was prepared but not issued.

In his report, Mr. Evershed discussed the costs of lands and amounts of land and power that would probably be required by lessees, cited the suggestions of Mr. Fanning concerning the same, and said "we must have all the land up to Elizabeth Street."

Mr. Ely presented a report to this meeting of December, on the condition of the right-of-way for the tunnel under the village of Niagara Falls showing valid releases from all property owners excepting the New York Central and Hudson River Railroad Company, The Niagara Falls Hydraulic Power and Manufacturing Company, and five individual land owners, three of whom

were ready to sign their deeds and from all of whom titles were eventually obtained.

On December 22, 1888, a meeting of the trustees was held, and Messrs. Gaskill, Kinsley and Gluck were constituted a committee to go to New York and negotiate with persons making a proposal that had been forwarded by Mr. Rankine. These negotiations were unsuccessful.

On January 5, 1889, a resolution was passed appointing Mr. Rankine as incorporator, he agreeing to accept an equal share with the other stockholders in lieu of other payment for "his legal services past and to come."

Meanwhile there were no outward evidences of the interest or efforts of Messrs. Rankine and Stetson, and the "Great Enterprise" seemed again to languish. Thus another winter, 1888–1889, wore away. But in Mr. Stetson the leaven was evidently finally working, for in February he suggested an amendment to the charter, clarifying and enlarging the rights to take and use the waters of the river and to locate and construct works therefor.

The measure was introduced in the Assembly on the 26th of February and in the Senate on the day following. Its management was entrusted to Mr. Ely. After some vicissitudes it was finally passed in both houses April 5, and on the same day received the approval of Governor David B. Hill.

On May 10, William B. Rankine made a statement at a meeting of the stockholders regarding his negotiations with Mr. Stetson.

At this time it was resolved at a meeting of the trustees that the unpaid portion of the subscription to the capital stock of the company be released and three shares, fully paid, be issued to each stockholder, representing the $300 cash paid upon each subscription and used for current expenses.

NEGOTIATIONS FOR SALE OF COMPANY UNDER OPTIONAL CONTRACTS

Thereafter matters between the Niagara and the New York interests were actively taken up. On July 5, 1889, Messrs. Stetson, Rankine and Edward A. Wickes, the latter recognized as a "Vanderbilt man," appeared at a meeting of the tunnel company board of directors held at the office of Superintendent Welch in the State Reservation at Niagara, and plans were then outlined by Mr. Stetson for the formation of a new corporation to be entitled The Cataract Construction Company, that would prepare a method of developing the power and act as the financial agent of The Niagara Falls Power Company. A preliminary agreement was presented under which the two companies would proceed towards the final execution of the project by The Cataract Construction Company as the contractor and representative of the tunnel company about to be acquired.

The draft contract as presented gave evidence of careful preparation and was thoroughly considered at the morning meeting and at adjourned meetings in the afternoon and evening and until an early hour the following morning. It was amended upon the motion of the tunnel company directors in a great many of its details and finally approved and executed, provisionally, by both parties with the understanding that a fair copy should be prepared for formal execution.

The contract provided that the name of the Niagara River Hydraulic Tunnel, Power and Sewer Company of Niagara Falls, New York, should be changed, at its expense, to The Niagara Falls Power Company. This was done under authority of the meeting of the trustees, September 19, 1889, and by a proceeding under the general laws of New York, conducted by Mr. Ely and published November 11, 1889.

The preliminary contract contained a proviso that The Cataract Construction Company "would on or before the first day of December, 1889, enter into a proper and formal construction contract, of which the performance shall be secured by subscriptions, satisfactory to the board of directors of the Niagara company, to the cataract company's treasury to the amount of at least $600,000 (a) to construct the first section of the tunnel; and (b) to pay into the treasury of the Niagara company upon or before the first day of January 1892, the sum of one hundred thousand dollars."

As the first day of December, 1889, drew near, the indications increased that further delay was to be expected, and on November 28th, a letter was received from Mr. Rankine asking an extension of thirty days. The directors of the Niagara company took no action upon the request and asked Mr. Rankine to meet them. On the 30th of November the board met again with Mr. Rankine present, with the result that an extension was granted to January 1. On the preceding day Messrs. Stetson and Rankine visited the falls and obtained a further extension until February 1, with a modification of the preliminary contract of July 5, 1889, so as to include additional work and compensation to The Cataract Construction Company of both bonds and shares of a par value of $2,200,000 each. At this time the purchase of Grass Island for $2000 was authorized, as well as an agreement of the preceding day granting to the Niagara company the right to construct its tunnel across and under the hydraulic canal of The Niagara Falls Hydraulic Power and Manufacturing Company, for $20,000 payable in cash and bonds.

Again, on January 27, the period of execution of the formal Niagara-cataract contract was extended to March 31, and later to April 1, 1890.

On February 18, 1890, the trustees of the Niagara company authorized the

Purchases of land from twenty different owners for the total sum of . . .	$ 291,500
Increase of capital stock to	2,000,000
Issue of 40-year five per cent first mortgage bonds	6,000,000

Call of stockholders in meeting, March 8, 1890, to authorize the issues of capital stock and bonds proposed.

The entire share capital was represented at this meeting, and the issues of stocks and bonds proposed were unanimously authorized by the twelve shareholders.

Early in March, Mr. Ely called the attention of Mr. Stetson to several important reasons why no further options should be given and why the proposed formal contract should be executed without further delay, among which were the following: A commission on statutory revision had reported to the legislature of 1890 and was pressing for passage bills with reference to the general laws of the state governing corporations which contained provisions that Mr. Stetson and Victor Morawetz, who was now acting with Mr. Stetson in the capacity of counsel, deemed inimical to the plans of the Niagara and cataract companies.

In the correspondence that ensued, Mr. Ely and the president and secretary of the Niagara company convinced Mr. Stetson of the necessity of proceeding without further delay to make the formal contract. Into this decision entered strongly the fact that all of the optional land contracts hinged upon the execution of the formal contract on or before April 1, 1890.

The Cataract Construction Company became the agent of The Niagara Falls Power Company "in the negotiation of leases and contracts, the employment of operating forces for its plant, and the collection of its accounts for rentals due under its leases."

OPTIONAL CONTRACTS THAT RESULTED IN SALE

The financial negotiations of the Gaskill Tunnel and Sewer Company may be summarized as follows:

The capital subscribed by the trustees in 1886 amounted to $200,000, of which $3600 (one and eight tenths per cent) was paid in cash. In 1889, the unpaid balance was cancelled and the subscribers released therefrom.

The contracts for purchase of lands and various rights were mainly optional agreements, with prolonged periods for their determination, but mostly on or before April 1, 1890.

The first efforts to procure capital were directed to the principal financial centers with much formality in opening books of subscription to the share

capital of the company, and with personal solicitations where the Great Falls were well known, but no encouragements to expect subscription to the stock were received.

The English negotiation, under auspices thought most favorable, was authorized for the sale of the rights, franchises and shares, for the sum of $650,000, and a tunnel company was formed in London to facilitate the preliminary examinations and to provide for the expenses thereof. After several months of investigation, and the preparation of a financial prospectus, the contracts of option were surrendered and the business declined.

Then followed numerous efforts in the United States for the sale of bonds secured by a first mortgage upon the franchise, rights and privileges acquired. These were not successful.

The promoters of the Gaskill tunnel enterprise were discouraged. Options and payment on contracts for land were maturing. The sale of the entire property and rights of the company appeared to be the only way to avoid financial embarrassment.

Negotiations for a sale of the company with all its assets had been pending with Francis Lynde Stetson, and continued at intervals for several years to April 1, 1890, when a formal agreement was made between The Niagara Falls Power Company and The Cataract Construction Company for purchase by the latter of all the capital stock of The Niagara Falls Power Company and for the payment of certain liabilities for services and contracts for lands and rights-of-way.

Payments were authorized in cash and in bonds as follows:

In payment for the entire capital stock of The Niagara Falls Power Company and the services of its trustees, officers and counsel, to January 1, 1892, in first mortgage bonds of the Niagara company		$174,000
For right-of-way under and across the canal of the hydraulic power company as provided in the agreement of December 31, 1889 ($5000 previously paid)		15,000
In payment for lands under contract in bonds		187,000
Total Bonds		$376,000
in cash		106,500
Total Payments		$482,500
Constituting a purchase of the		
Entire capital stock at	$174,000	
Lands, purchased and under contract	293,500	
Right-of-way for discharge tunnel	15,000	$482,500

Following is the distribution of purchase price:

Francis R. Delano, trustee, as reimbursement of his disbursements for account of the company	$ 4,000
W. Caryl Ely	12,000
Estate of Thomas Evershed, deceased	15,000
Benjamin Flagler	12,000
Charles B. Gaskill	14,000
James Fraser Gluck's assignee	12,000
Myron H. Kinsley	12,000
Raymond S Perrin, for services in English negotiations	5,000
Estate of A Augustus Porter, deceased	10,000
Peter A. Porter	12,000
William B. Rankine, for services to and including June 1, 1889	14,000
Michael Ryan	12,000
Francis Lynde Stetson, for services prior to June 1, 1889	16,000
Henry S. Ware	12,000
Thomas V. Welch	12,000
TOTAL PAYABLE IN BONDS	$174,000

Although The Cataract Construction Company thus acquired the ownership of the entire capital stock of The Niagara Falls Power Company, it was considered good business policy to retain publicly, as well as privately, the association and co-operation of the local representatives on the board of trustees of the Niagara company, while the New York stockholders were represented by the board of directors of The Cataract Construction Company, particularly as the latter company was engaged in the formulation and execution of the Niagara company's plans of construction, operation and finance.

THE NIAGARA FALLS POWER COMPANY

1889–1899

During the ten-year period from July 5, 1889, when the preliminary and optional contract was made with The Niagara Falls Power Company for the acquisition of its shares and assets by The Cataract Construction Company, until the contract of May 31, 1899, between the same parties was executed, by which all contractual relations were cancelled, all the nine trustees of the Niagara company were selected from stockholders identified with Niagara Falls and its vicinity, with the exceptions of the election of Coleman Sellers, of Philadelphia, in 1893, as president and chief engineer, and of Arthur H Masten, of New York, in 1896, in place of Frank A. Dudley, resigned. The following trustees served upon the board during this period:

Francis R. Delano	1886 –*1891
W. Caryl Ely	1886 –*1898
Benjamin Flagler	1886 –*1898
Charles B. Gaskill	1886 –*1894
Myron H. Kinsley	1886 –*1891
A. Augustus Porter	1886 –*1887
Peter A. Porter	1886 –*1898
Henry S. Ware	1886 –*1892
Thomas V. Welch	1886 –*1891
Alexander J. Porter	1888 – 1893
Henry Durk	1892 – 1893
Lauren W Pettebone	1892 –*1898
De Lancey Rankine	1892 – 1893
Frank A. Dudley	1892 – 1895
Coleman Sellers	1893 –*1898
William S. Humbert	1894 – 1898
Charles A. Sweet	1894 –*1898
Edmund S. Wheeler	1895 –*1898
Arthur H. Masten	1896 – 1898

* Deceased

By the purchase of the tunnel company, the responsibility for the enterprise was assumed by The Cataract Construction Company, representing the subscribers to its construction fund and the owners of its capital stock.

CHARLES B. GASKILL
1841–1919
PRESIDENT
THE NIAGARA FALLS POWER COMPANY[1]
1886–1894
COLONEL UNITED STATES ARMY
SERVED WITH DISTINCTION IN CIVIL
AND SPANISH-AMERICAN WARS

It was this company that made the investigations in this country and abroad as to the state of development of the several arts for the production, transmission and use of power from falling water.

[1] Incorporated 1886 as Niagara River Hydraulic Tunnel, Power and Sewer Company; name changed, 1889, to The Niagara Falls Power Company.

The results of these researches, the organizations adopted for scientific guidance, the decisions made and the constructions carried out, are described in the following chapters.

COL. CHARLES B. GASKILL

Colonel Gaskill was honored by the highest positions in public service that his friends of the community could give. He maintained his interest in the military affairs of the state. Transportation and manufacturing, however, represented his principal investments. These increasingly demanded his attention as the village of Niagara Falls increased in population, activity and resources.

As president of the power company from its organization of 1886 to 1894, several years after he and his associates sold their interests, he brought his experience of about fourteen years in manufacturing with water-power from Niagara River and his broader experience with men of large affairs in national and other activities, to the introduction and development of the Evershed project.

The project of the hydraulic canal proposed by Judge Augustus Porter by circular of January, 1847, reached a consummation some thirty years later, and Colonel Gaskill has the record of being the first user of the water of the hydraulic canal for industrial purposes.

To have been connected with the early stages of each of the two projects, in one as first user of power, in the other as leading promoter and president, which were merged in 1918 into the consolidation entitled The Niagara Falls Power Company, is the unique distinction which belongs to Col. Charles B. Gaskill of Niagara Falls.

Gen. Nelson A. Miles, under whom he served, wrote of him:

> Colonel Gaskill was one of the best officers and noblest of men that I have ever known. A more thorough, conscientious, honest patriot never wore the uniform of the United States Army. His whole heart and mind were interested in the welfare of his command and in the service of his country. Whatever command he had, whether a company or regiment, it was in the best possible condition. The service had few, if any, more efficient officers.

NIAGARA FALLS

THE GREAT MANUFACTURING VILLAGE OF THE WEST

Here is a power almost illimitable; constantly wasted, yet never diminished—constantly exerted, yet never exhausted—gazed upon, admired, wondered at, but never hitherto controlled.

From the Prospectus of the
Niagara Falls Hydraulic Company
Caleb S. Woodhull, President
1853

THE EVERSHED TUNNEL PROJECT INVESTIGATION AND MODIFICATION

1889–1890

Chapter VIII

To gather the streams from waste and to draw from them energy, labor without brains, and so to save mankind from toil that it can be spared, is to supply what next to intellect is the very foundation of all our achievement and all our welfare.

Justice Holmes
U. S. Supreme Court

THE EVERSHED TUNNEL PROJECT INVESTIGATION AND MODIFICATION

CHAPTER VIII

THE EVERSHED PROJECT AND THE NIAGARA PROBLEM

IN the summer of 1889 the story of the century-old attempts to harness the falls of Niagara finds the new tunnel project in the hands of Francis L. Stetson and Edward A. Wickes of New York and William B. Rankine of Niagara Falls. They had acquired the right to purchase the Niagara River Hydraulic Tunnel, Power and Sewer Company (organized in 1886 by the Gaskill group) which proposed to develop power in accordance with the plan and advices of Thomas Evershed and they had organized The Cataract Construction Company of New Jersey, for that purpose. Various attempts to finance the project had proved futile, and in August they offered a half interest in the enterprise to Winslow, Lanier & Company, New York bankers. Edward D. Adams,[1] a partner in the firm, was delegated to conduct an investigation to determine the merits of the proposals.

The project as outlined in the preliminary plans of Thomas Evershed, dated July 1, 1889, and described in the preceding chapter, was for the formation of an industrial town. Mills and factories within an area several hundred yards wide and extending along and up the river for a mile and a half were to be driven by individual water-wheels supplied from a dozen inlet channels or short canals. The water from the wheels at the bottom of the various wheel-pits would discharge through short tail-race tunnels into a main discharge tunnel about 2½ miles long emptying into the lower river It was proposed that this tunnel should be adequate for the discharge from 238 wheels, each supplying 500 horse-power to a single factory, or a total of 119,000 horse-power.

It was seen at once that the novelty and magnitude of the project introduced unsolved and far-reaching problems. For what purposes and where could so large an amount of power be used? The population of Niagara Falls in 1890 was only about 5000.

Was the scheme of building up a new industrial center for using power that "far exceeds the combined available power in use at Holyoke, Lowell, Minneapolis, Cohoes, Lewiston and Lawrence" a promising venture? Was it wise to construct a costly tail-race tunnel instead of following the old method by employing a long inlet hydraulic canal?

[1] His connection with the enterprise has been continuous during the thirty-seven years intervening between the original investigation and the completion of this history.

Was the old plan of placing the mill over or near its own water-wheel adapted to a project of unprecedented magnitude, or could power produced at one place be supplied to several customers from a consumer system as was the practise with gas and water and electric light?

Could the power be distributed locally or transmitted to a considerable distance by shafts or belts or cables, by compressed air or water pressure, or would electricity which was doing wonderful things in a small way be capable of handling power on a scale and over distances which far exceeded what had been accomplished?

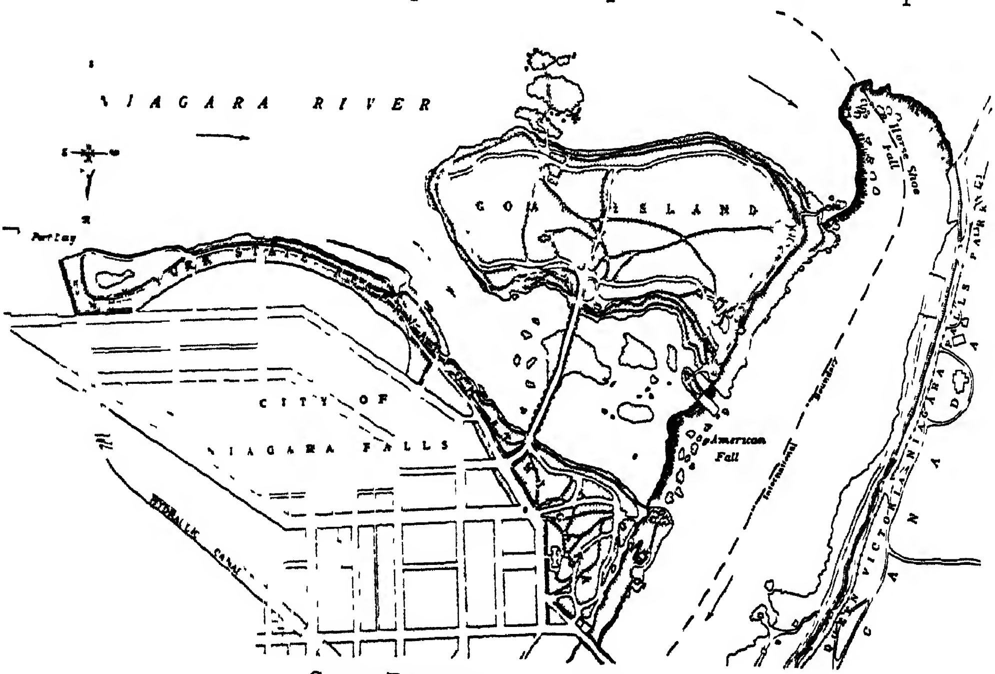
Could Buffalo, population about 255,000, the far-distant Mecca for Niagara power, be reached by any practicable method?

In short, the inquiry involved broad questions as to the best general engineering plan for power development at Niagara; the practicability of the proposed system employing many inlets and many wheels with a common discharge tunnel; the transmission of power over moderate or considerable distances—all of which meshed into the questions how and where the proposed enormous amount of power could be so used as to justify the undertaking financially.

DISCHARGE TUNNEL VERSUS CANAL INLET

The proposed discharge tunnel was a practical solution of the specific problem presented by the conditions then existing at Niagara Falls.

It will be seen by the following plan of Niagara Falls at that date, that the State of New York had acquired ownership of the land and its riparian



STATE RESERVATION AT NIAGARA
From Dow's "Anthropology and Bibliography of Niagara Falls"

water-rights extending along the river bank from the Great Falls, 1 mile upstream to Port Day, and on the bank below the Great Falls to the foundations of the Suspension Bridge. All of this property, with Goat Island and other small islands, comprising the state reservation, from which industrial establishments had been removed and permanently excluded.

Port Day and its so-called hydraulic canal, supplying the factories located at the end of the canal basin of the Schoellkopf company, as shown on the accompanying illustration, had been constructed many years before this period. The village of Niagara Falls, had been established mainly within the triangle formed by the upper and lower river and the hydraulic canal. The terrain within the triangular space was unavailable for power developments because, owing to its permanent inhabitants, it was practically impossible to acquire in this area the right for a second water intake and canal, or sufficient land for industrial improvement.

These conditions, and considerations of economy in capital expenditures, required a power company seeking a location to place its water intake above the reservation and as near as possible to Port Day on the eastern side, and its raceway, or its water-wheel discharge, by the shortest line to the lower river where discharge could be made immediately below the Suspension Bridge.

A tunnel from the river bank east of Port Day to a point below and adjoining the bridge foundation thus became the only practical solution of these difficulties, and the large tract of sparsely occupied land between the river and the lines of the New York Central and the Erie railroads, extending up the river to and beyond Gill Creek to Connor's Island, recommended itself as the natural location for a new industrial community.

INDIVIDUAL WATER-WHEELS VERSUS POWER TRANSMISSION AND DISTRIBUTION

The Evershed plan[1] made provision for 238 mills, each supplied with power by its own 500 horse-power water-wheel. Twelve cross tunnels aggregated about 3 miles in length and the main tunnel was 2½ miles long and 14 feet in diameter.

Difficulties soon appeared. The construction of over 5 miles of tunnel and 238 wheel-pits aggregating some 4 miles more, practically all by rock excavation in a hard limestone deposit, indicated the economy in fewer wheel-pits and a lessened length of tunnels and inlet-canals. The likelihood of ice in some 3 miles of comparatively shallow inlet-canals promised to be a serious menace to dependable operation. Furthermore an industrial development of

[1] For drawings see Chapter VII, Volume I, and Chapter XVII, Volume II.

hundreds of mills equivalent to that of half a dozen prominent manufacturing communities comprised within a restricted area was visionary, requiring a generation in time and fortunes in expenditures to create.

Obviously power production should be concentrated into fewer units and if practicable the power distributed to the places where it could best be used. Without transmission the water-wheels and the mills must come together, to the detriment of each; but with transmission, the power could be produced by the most efficient and economical means, and the mills and factories located to their best advantage in operation.

It was also recognized that large initial investment would be necessary and that a slowly growing industrial community would produce a tardy income, while the supplying of electric current to the established communities of Buffalo and Tonawanda would afford an immediate income for meeting interest charges on construction costs.

POWER DEVELOPMENT AND ELECTRICAL TRANSMISSION

It was realized that the project involved problems of great magnitude and that technical advice of a high order was needed in several departments of engineering. Immediate steps were taken to secure such assistance, particularly in the matter of power transmission by electricity.

MR. EDISON ON ELECTRICAL TRANSMISSION

Naturally, among the first experts to be consulted regarding the Niagara project was Thomas A. Edison, not only because he designed and introduced the electric distribution for incandescent lighting by direct-current systems then in use and rapidly extending, but because a large number of the financial group then considering the Niagara-Evershed project were associated with Mr. Edison as directors and stockholders in electric companies bearing his name.

While Mr. Edison was abroad in September, 1889, he was asked by cable, respecting the project to transmit Niagara power to Buffalo:

> Has power transmission reached such development that in your judgment scheme practicable

He cabled from Havre, September 28th:

> No difficulty transferring unlimited power. Will assist. Sailing today.

Mr. Edison had made a survey, in 1886, of the situation in Buffalo and what he termed a rough estimate of the cost of transferring power from the turbine shaft at Niagara Falls to the center of the city of Buffalo.

His estimates, it is stated, were based upon the delivery of 5000 horsepower, being the estimated net amount from about 6800 horse-power taken

from the shaft at the falls and transmitted the 22 miles at a loss of about 20 per cent on the wires, and about 6 per cent on dynamos and "reducers." He proposed to use 6000 volts, which he then considered as high as any commercial enterprise should use, and with his new reducers at Buffalo, step-down the voltage to 300–400 volts for power and 200 for lights.

THOMAS A. EDISON AT WORK
IN HIS LABORATORY

It was during the year 1889 that the partisans of direct and alternating current resorted to the press in their efforts to create public opinion for or against their favorite current. The alternating current was new, but its use, principally for incandescent lighting was rapidly extending both in this country and abroad. The antagonism in the competition of electrical industries reached such a point that both currents were recommended for use in the proposed establishment of state execution[1] by electric current, and there was

[1] The only current used at Sing Sing Prison has been the alternating, single-phase, sixty-cycle current.

much discussion as to which current would be preferred by the executioner and the criminal.

Mr. Edison was written, October 16, 1889, that the enterprise was then regarded as a project to furnish power for use in the immediate vicinity of Niagara Falls by electrical or other methods, and that a comparatively small amount of light would also be consumed there; that if the project upon this basis would return a fair rate of interest on the capital invested, one could safely engage in the business, trusting to development, under good management, for the larger results to be expected and that as one of the means of obtaining large profits, consideration would be given to the supply of power in Tonawanda and Buffalo and to the distribution of light in those places.

Mr. Edison confidently believed the Niagara-Buffalo transmission[1] feasible by the continuous-current system. He welcomed such a favorable opportunity to estimate the efficiency and commercial value of the direct current and at once resumed his consideration of the Niagara-Buffalo transmission, undertaking a new survey of the conditions.

An examination was made on his behalf in 1889 by C. J. Field,[2] of Brooklyn, regarding the proposed transmission to Buffalo, by laying cables in the river channel. He reported, November 11, estimating that the cable line from power-house in Niagara to Black Rock, at the northern boundary of Buffalo, would be 15 miles via the channel on the Canadian side of Grand Island, and, by using an underground line directly across Grand Island, the distance would be reduced to 14 miles. The river bottom was found generally uniform and nearly free from holes or shoals. There were several rocky places but as they did not extend across the river-bed, they could easily be avoided in laying the cables. It was considered entirely feasible to lay and use cables in the channel of the river.

Mr. Edison recommended the 14 mile line directly across Grand Island, with the cable in a trench and crossing the river at Buffalo and Niagara by a pole suspension. Mr. Field's report included the results of his inquiries as to ice, anchorage, temperature of water, depth of river, canal and ship channel dredging, etc.

About this period Mr. Edison cabled to Siemens Brothers of London, for an approximate estimate for the sizes and lengths of cables probably desired. His comment upon the reply was, "The prices are rather high when 45 per cent is added (duty) and I think they can be made in this country."

Mr. Field reported that "there is at present about 4000 horse-power at Tonawanda, which is continually increasing. There are two electric street

[1] *Cassier's Magazine* of March, 1893.

[2] General Manager, Edison Electric Illuminating Company, of Brooklyn.

railways, also an electric light station contemplated, but are holding off for the further development of this problem. At Buffalo there is estimated from 40,000 to 50,000 horse-power. The city is spending more than $300,000 for lighting, of which the gas company is still getting two-thirds."

The estimate received from the laboratory of Mr. Edison, on November 14, 1889, amounted to $5,243,000, as the cost of producing but not of distributing, by means of a

> Main tunnel, with capacity of 120,000 horse-power;
>
> Hydraulic development with turbines and rope or cable transmission to surface;
>
> Niagara electric station for production of continuous current for transmission by wires in cables to Buffalo:
>
> Three sub-stations in Buffalo for distribution of light and power, but not including systems of distribution to consuming customers.

An income of $880,000 net per annum was estimated from a gross annual revenue of $1,402,000 sold en grosse at the sub-station terminals in Buffalo

The prospective income was alluring, but capital was particularly cautious at that time in view of the possibility of a cheaper and more direct form of transmission becoming available before the main tunnel could be completed. It was therefore decided to continue investigations while plans were being prepared for the construction of the tunnel, the backbone of the enterprise.

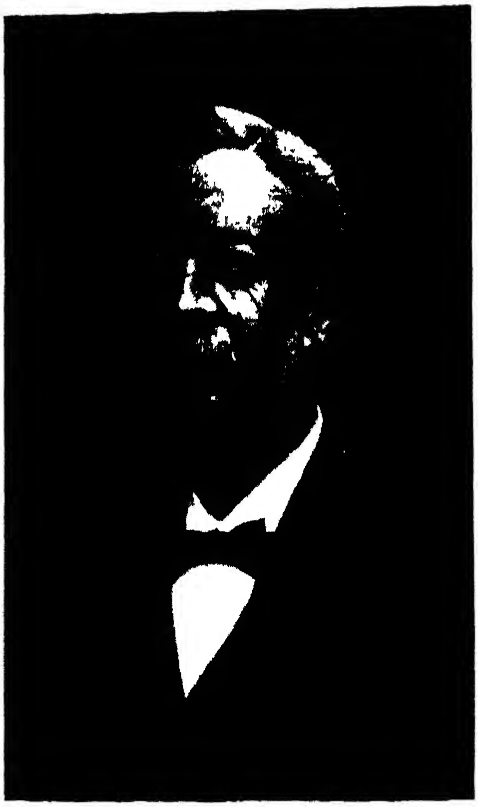
The hydraulic features of the project were still under consideration, and the problems of distribution had not yet gone beyond those of local use, from a central power source, for which systems of water under pressure, compressed air, and electricity were recommended.

The thorough examination and resulting opinion, as expressed by so eminent an electrician as Mr. Edison, were convincing that the use of electricity had not then been sufficiently developed for its economical and profitable distribution in long-distance transmission for power purposes.

The advantages of the alternating current in long-distance transmission were then exciting the attention of engineers and under these conditions it seemed desirable to continue the study of transmission plans until after the fundamental elements of the main project for primary units had been decided.

As Mr. Edison declined to accept financial compensation for his services at this time, an offer was made to pay the expenses of his investigation. To this suggestion he demurred, and after some estimates of the probable costs were figured, an offer was made to pay him $10,000 for his maps and statistics.

This offer was also declined, with the statement that he would prefer to keep his information.



HENRY MORTON
PH.D., SC.D., LL.D.
1836–1902
PHYSICIST AND ENGINEER
FIRST PRESIDENT OF
STEVENS INSTITUTE OF TECHNOLOGY
1870–1902

DR. MORTON ON ELECTRICAL TRANSMISSION

Dr. Henry Morton, president of the Stevens Institute of Technology, was retained as a scientific adviser and the documents in the case were submitted to him for analysis. He reported early in September, 1889, as follows:

In reply to your question respecting the practicability and economy of transmitting power in large amounts through long distances (say units of 1000 horse-power for 10 or 20 miles) by means of electric currents, I would say that the problem is not one which has as yet received anywhere its practical solution, and therefore we cannot say it is certainly feasible because it has already been done in such and such a case.

Large amounts of power have been transmitted to distances of 1 or 2 miles, and small amounts of power have been transmitted for long distances, such as 30 miles, but the combination of large amounts of power and long distances has not yet been realized in practise, and without doubt something new in the dimensions and proportions of electrical machinery must be developed in order to meet the requirements of such a problem as you propose.

Enough, however, has been done to furnish a sound basis for general calculations and estimates, and having gone over these with great care, in a variety of cases, I feel entirely satisfied that a plant could be constructed for the transmission of 1000 horse-power through a distance of 10 or 20 miles at such a cost as would make each horse-power available at the end of the line, costs from $10 to $20 per year; this including all interest on the cost of electrical machinery, line-wires, buildings and other structures, and the expense of maintenance as expressed in wages of attendants and costs of repairs. This does not include the cost of producing the power by turbines or otherwise at Niagara, which I have not examined or attempted to estimate.

For larger amounts than 1000 horse-power, it would be best to duplicate the plant required for the former amount.

In my estimation the difficulties, expensiveness and wastefulness of any pneumatic method of transmitting power for such distances, renders it unworthy of consideration in this connection.

The generation of an alternating current was then considered particularly interesting when produced at high potential, because it could be carried far and economically by the use of a small copper wire

The difficulties after transmission were the unsurmounted obstacles that prevented the use of the high-tension current.

The means for reduction of the voltage to safe and useful pressure in distribution had not been provided; the converters were yet to be designed and manufactured.

Scientists had theoretically demonstrated to their own satisfaction that the current could be controlled and distributed safely and economically as desired for use in motors as power. Their laboratories were working out designs and engaged in the construction of experimental machines. The results were encouraging but not commercial. Hope may have fathered the thought that the machines would be forthcoming; the stakes were high, the field was promising and the community was expectant; success meant fortunes; there was an unmistakable demand that lured the inventor; the pioneer promoter had both courage and confidence. The necessity was recognized as the mother of the inventions required.

Naturally there were different points of view. The pioneer sought information and soon learned that conservatism counseled delay, for safety, while leaders had visions of useful achievements almost within sight and grasp.

SPRAGUE ON ELECTRICAL TRANSMISSION

Among the earliest to recognize the economic advantages of transmitting electric current at high potential was Frank J. Sprague, a recognized authority on electrical matters. His early electric railway studies indicated the importance of 3000-volt current transmission on the trolley car. He believed

Frank Julian Sprague
D ENG., D SC., LL.D.
Electrical Engineer
Grad. U S Naval Academy, 1878
Mem. A. I. E. E. (Pres. 1892–1893)

that whatever potential might prove necessary for commercial operations would be adopted and means be found to divert its use from danger by protective control.

Mr. Sprague made important advances in the use and control of alternating currents of electricity at high potential, when experimenting in 1880–1881 at

the United States Torpedo Station at Newport, Rhode Island, when he proposed converters or reversed secondary coils.

Upon official request, he made a report September 13, 1886, to the Edison Electric Illuminating Company of New York upon the system of supplying light by the use of alternating current machines and converters (transformers).

After descriptive and mathematical demonstrations of the comparative value, in capital expenditure, and in the profit and safety of operation, he stated:

the whole question seems to me to be solved by a comparison, where long distances are used, between the two systems, and in this case the alternating current distribution unquestionably has the advantage.

There is no question in my mind but that this kind of distribution has come to stay and is going to be a formidable rival to the system of direct supply by continuous currents

These are significant facts and you cannot too soon take steps to prevent some one getting in the field ahead of you.

On October 31, 1889, in a report to an eminent physicist, regarding distance transmission, Mr. Sprague expressed the following views:

I do not think the problem to transmit power by electricity from Niagara Falls to several points at varied distances up to 20 miles, a sound one, commercially. Scientifically, of course, it is possible; but in view of the large amount of work which has to be done to develop a suitable plant, the risks of accident, the necessity of a secondary conversion, say in Buffalo, and the ordinary commercial questions which arise, seem to take this problem out of the category of those which may be specially relied upon to be successful My own feeling is simply this with ample means, and with an assured demand for the power, I would not hesitate to transmit any amount of power from Niagara Falls to Buffalo, but, although I would feel capable of doing this, if I were at the same time asked if I would invest any money in the enterprise, I would decline to do it, because there are so many questions which determine the success or failure of such an enterprise independent of the mere special transmission of the power between two points. I think the more serious problem would be the distribution of the power after having gotten it to Buffalo. There would be no particular difficulty, I take it, in building alternate-current machines, say of 10,000 or 20,000 horse-power and transmitting the power at 7000 or 8000 volts potential, but such a potential would not be allowed overhead in the streets and there would be great difficulty even in carrying it underground. Converters would be necessary, or a big general receiving motor which would operate other dynamos.

As regards the use of the converter, there has not yet been produced a good single circuit alternate-current motor, and as for secondary conversion, where the station is operated by the large motor, I think the losses are too serious to make it practical. In short, my position[1] in the matter is—I can transmit and distribute this power, but

[1] Sometime later Mr. Sprague advised the Edison interests, in a formal report, that they should embark actively in development along alternating-current lines to meet the problems of the transmission of energy over long distances and to carry on this work simultaneously with the development of their continuous-current system.

I think it a problem so uncommercial, in view of the attendant difficulties and risks, that it is better to keep out of it

PROFESSOR ROWLAND ON POWER TRANSMISSION

It being recognized that the further discussion of the relative values of continuous and alternating currents for commercial purposes involved serious

HENRY AUGUSTUS ROWLAND
PH D, LL D
1848–1901
PHYSICIST
FIRST DIRECTOR OF THE PHYSICS LABORATORY
OF JOHNS HOPKINS UNIVERSITY

questions as to danger, control, efficiency, capital outlays, expenses of maintenance, and knowledge of the electrical science in its latest manifestations, the services were secured, about October 1, 1889, of Henry A. Rowland, physicist, of Johns Hopkins University of Baltimore, for advice in the investigation and development of the enterprise.

In submitting the problem to Professor Rowland the bankers outlined their position as follows:

While it was generally understood that the development of the transmission of power by electricity had proceeded recently with great rapidity, no definite information seemed available to justify investments in hydraulic power upon the assumption that the science of long-distance electrical transmission of power had reached a commercial basis. The main questions were as to the economical transmission of power and light for commercial purposes, and the adoption of a hydro-electric system suitable for the enormous amount of Niagara power available and the conditions of the demand therefor. The progress attained in the science of electricity, and the state of the art of its application, were conditions that the bankers wished to understand before capital should be invited to participate in the venture proposed.

Professor Rowland undertook a report considering, first the general theory of the subject of transmission of power to great distances with respect to economy, etc., after which, he stated:

> I would treat of the means at our disposal for carrying out the theory. This latter would include a discussion of the different systems in use at the present time. But the great distance to which the power is to be carried makes an entirely new problem for the electrical engineers.
>
> That power can be transmitted to a great distance by electricity and with reasonable certainty is a matter well determined at the present day (1889). But the practical and commercial problem is of a different nature from the scientific one and may be stated thus:
>
> At what distance from cheap water-power can such power, transmitted electrically, compete with steam in cost and certainty of operation?

To assure certainty of operation, especially in competition with steam-power, Professor Rowland recommended bare copper wires on a pole line, or overhead system of transmission, instead of the use of underground cables carrying high potentials.

He stated that the method of electric transmission by alternating currents had great possibilities, and many persons thought it the method of the future. The higher the potential, the greater the economy, but the greater the dangers of its use. He considered the limit at the state of the art of its control at that period to be 3000 volts at the dynamos, and at the motors about 2000. At that time, he said, the alternating system was not a practical success. In case of distance transmission, however, of electricity for both lighting and power use, high-tension currents must be employed.

In the use of the continuous current for which he presented a plan for transmission to Tonawanda and Buffalo, he described the method of coupling

the dynamos in series to obtain any potential desired, and recommended the Edison type of machine as the best adapted to this purpose, as such machines could be insulated to produce successfully 1250 volts, but were seldom constructed in this country of higher power than 250 horse-power.

After presenting several systems for the transmission of continuous current generated in a central station at Niagara Falls to local users and to Tonawanda and Buffalo, Professor Rowland gave the following summary of his conclusions in his study of the Niagara problem:

1. That the wire rope method of transmitting power was best and cheapest up to a mile or even two miles, when possible to employ it.

2. That at two to five miles distance electric transmission could compete with steam-engines of all powers using coal, and that it would pay the consumer to adopt it in all cases where his engine was not of the very highest type and new. In this latter case he would probably wait until his boilers wore out.

3. That at Tonawanda competition would be successful with engines up to nearly 1000 horse-power, provided coal were the fuel, and not furnace gases or the refuse from sawmills.

4. That at Buffalo it would pay the owners of 100 horse-power engines to throw them away only if they were old and poor, and that difficulty would probably be found in inducing them to do so until the electrical scheme had been working for years and had proved to them that electric power is as certain as steam Below 50-horse-power units the competition with steam would probably be successful, provided enough horse-power could be sold, which he considered doubtful. With enterprising business management, the scheme might succeed, but there was much uncertainty about it.

5. That there was very little danger of broken communication, except from storms of the worst character or by malicious persons. As iron poles, near together, had been used in his project for the main lines, only the most violent storms acting on frozen sleet hanging to the wires could break them down, and this danger could be diminished by using silicon bronze instead of copper for the wires, or by making them fewer in number and larger. As to injury from malicious persons, the danger of instant death would prevent all but the most persistent persons from interfering. Undoubtedly, proper insulators could be devised to defy the weather but not without trouble and experiment at the high potential used.

6. That no electric company should be allowed to carry out such a scheme, as he did not believe any of them were prepared for it or had the highest class of electricians capable of dealing with such a problem, who were not already engaged in their own personal work to such an extent as to keep them from devoting their time to such a project. The proper way would be to engage an electrical engineer at a high salary to stand between the company and the electric manufacturers. Such an engineer would save his cost many times. Let him spend six months or a year studying the matter and find how much power he was certain of selling in the different places and at what price. Then put up a plant capable of enlargement and work it a long enough time to be

assured of success. Then enlarge the plant, first erecting machine shops for the manufacture of dynamos and motors unless very good terms could be made with the electric companies. A portion of the profits could then be derived from the sale of motors to the consumers of power. In this way, with a competent electrician, and economical as well as active business management, he believed a success might be made of it. At all events, the capital necessary to try the experiment would not be excessive, while the dynamos and copper wire, which constituted the greater portion of the expense, would always meet with a ready sale.

7. That no step should be taken before canvassing the two cities and the surrounding country and finding how much power could be sold and at what price.

Professor Rowland stated that he had used potentials no higher than those of many electric light wires in all large cities, and believed they could be used with some little trouble. He thought it might be well, however, to take into account the recent agitation with reference to the subject and consider the possibility of laws being passed to prevent the use of high potentials, as they had already been in England, or to force the system underground as in New York.

MR. HERSCHEL[1] ON POWER DEVELOPMENT

After a careful examination, with the personal assistance of Dr. Morton, of the questions involved in the papers submitted with the prospectus, the bankers sent the documents to Clemens Herschel, hydraulic engineer, for a report upon these plans from the standpoint of the hydraulic engineer and of the manager of water-power property.

Mr. Herschel referred, in his report of August 28, 1889, to his long familiarity with the conditions prevailing at Niagara, and made the following comments upon certain features of the project submitted for his consideration.

Comparing with the mill-power developed at the manufacturing districts in New England, he considered the total provision of about 300 acres at Niagara Falls quite insufficient for the local utilization of 120,000 horse-power. The average power in use at Holyoke in 1890 amounted to less than 200 horse-power per acre.

He considered the "income assured" in the prospectus entirely unreliable; based upon the cost of steam-power from coal, such income could not be obtained. The prices quoted varied from $2 to $65 and $83.33 per horse-power per annum and represented such irregularities in calculation that they also suggested uncertainties and doubt as to their origin and reliability.

Although Mr. Herschel recognized that improvements and inventions were following each other so rapidly in the electrical art, that even electricians were doubtful of the costs of Niagara power transmitted to Buffalo, he felt justified

[1] See portrait, Chapter XXVIII, Volume II.

in assuming, on the basis of a comparison with the cost of steam-power, that it would be worth at least $30 per electric horse-power per annum in that city.

He considered the transportation facilities at the site in question certainly superior, and Niagara a very favored place for freight rates.

In view of the years required for the establishment of a manufacturing community, Mr. Herschel suggested the construction of smaller works than those proposed. "I think," he stated, "it is characteristic of water-power adventures, that they require a large outlay before any income can be expected; and even upon completion of the work the income increases slowly, from small beginnings up to profitable proportions. I think that the plans at Niagara Falls, if carried out prudently, would be profitable also, but not right away."

DR. SELLERS'[1] EARLY REPORTS

After careful inquiries for an engineer of broad experience in mechanical and electrical problems, and free from professional association with any electrical manufacturing company that might make it difficult for him to render impartial decisions, Coleman Sellers of Philadelphia, was engaged about October 1, 1889, to investigate the conditions at Niagara Falls, to advise as to the development of power and to consider the relative merits of the systems available for local and distant use, the extent of their commercial application, their economies as compared with steam, and their practical application to the project for the development of Niagara power under some, if not all, of the conditions of the Evershed plan.

Dr. Sellers made three formal reports during that period to January 1, 1890, from which date his services were permanently established as consulting engineer of The Cataract Construction Company.

He expressed the opinions:

1. That the Evershed project was practicable and, under judicious management, would prove economical in the production of power. As presented by the prospectus and map, it was, in effect, simply an idea, that might prove advantageous to work out under the guidance of the highest attainments in engineering

2. That there was a reasonable certainty of transmitting the power as electricity 20 miles, for profitable sale at the point of delivery, at less than the cost of steam-power generated from coal at the same place.

3. That other methods of power transmission were in successful use besides the usual shaft-and-belt transmission, but their economy was limited in distance, varying according to special conditions, within a radius of about 5 miles. Mention and brief descriptions were given of transmission by telodynamic, hydraulic and pneumatic methods. Because pneumatic transmission was being replaced in various mining operations by the

[1] See portrait, Appendix A, Volume I.

use of electrical methods, these systems should be very carefully studied, as they were promising and the machines for their use becoming available with excellent results.

4. That large factory operations were now conducted by the use of large steam-engines, which, notwithstanding the known loss in transmitting power by line shafting, gave better results than many small engines scattered about the works, each directly driving its own machines. "Electricity seems to court division, and small motors attached to the machines may do better than a combination of large motors at one place giving motion to shafting after the manner of large steam-engines."

5. That this enterprise would supply the cheapest water-power in the largest quantities that had ever been produced, and this with an element of unusual stability.

6. That much economy in expenditure of capital, as well as in the operation of the plant, might be secured by skillful engineering, in determining the velocity of water in the discharge tunnel or tail-race and intake canals, and in the design of hydraulic machinery.

7. In establishing prices for power it should be constantly borne in mind that, although power was then available in manufacturing centers, at about $16 for 12 hours' use, even at the same price Niagara power would be much cheaper because it would be for 24 hours' use, and no provision would need to be made for depletion of reservoirs or repair of retaining dams

8. That it would be advisable to keep in view the chance to obtain control of the hydraulic canal at Niagara Falls.

9. That geological conditions and the records of river flow should be critically examined. Local observers of wide experience and the oldest residents had been interviewed regarding the lasting qualities of the limestone rock and shale, through both of which the tunnel would probably pass. The consensus of opinion was that the shale would wear well and the tunnel need no lining

10 That the probable cost of the discharge tunnel, inlet-canal, one cross tunnel, ten wheel-pits, and accessories, was estimated at about $2,000,000 for the first section of the project, to develop 20,000 horse-power. This total included ten double water-wheels of 1000 horse-power each, and cables from wheels to surface to the first jack-shafts, also the cost of the land, water-rights, franchises and property acquired

11. The uniform distribution of 2000 horse-power to each wheel-pit, and the carrying of this in blocks of 1000 horse-power to each of the mill-sites, one on either side of the pit, would enable the property to be rented to advantage even to small users, as the rope transmission in some cases would make it possible for whole rows of small industries to take the place of any one large factory.

The later reports of Dr. Sellers included suggestions for the letting of contracts for tunnel and other excavations and for the reduction in the number of inlets and changes in their location, that would lessen the cost of construction of a first section of 20,000 horse-power development and permit the occupation of necessary space for railroad tracks and other service facilities of the mills.

In commemoration of Dr. Coleman Sellers, and as a memorial of his wise counsel and valued services to the Niagara enterprise, this history is dedicated to him by the author. Lewis B. Stillwell has written a tribute to his memory, which appears as Appendix A to this volume.

CONCLUSIONS OF PRELIMINARY INVESTIGATION

These and other reports from hydraulic and electrical engineers of varied experience and recognized professional standing, together with numerous personal conferences on the same subjects, brought definite views to the financial syndicate of the Evershed project.

Upon a careful analysis of the conditions that obtained at Niagara, it became apparent that commercial considerations required the modification of the Evershed plan.

In view of the authority conferred by state charter for use of the waters of Niagara River without limitation,[1] and the general conviction that a market could eventually be found for a large amount of power, it seemed clear that success lay in the direction of a development upon an unprecedented scale.

The uncertainties were mainly financial and engineering. A course must be found which would retain the advantage to be derived from the production of power in vast quantities, but which would still keep the capital expenditures within such bounds that provision for fixed charges could be made readily, after construction, out of receipts during the period of growth. It was recognized that a large and ready market was waiting at Buffalo, with its population of 256,000, but in that direction the way was opposed by intricate scientific and economic problems that might prove very difficult to solve.

Since it was evident that a discharge tunnel was essential to any plan that might be adopted, and the engineers advised that it be constructed, at the outset, of sufficient capacity to provide for an eventual development of a large amount of power, the entire cost of this tunnel was necessarily included in providing for the initial outlay of capital.

As there appeared to be a good prospect of disposing of 20,000 horse-power locally at not less than $9 per annum for 24-hour use, an annual gross income of $180,000 from an initial development of that capacity seemed assured within a reasonable time. This would suffice to carry the $2,000,000 cost of such an installation as estimated by Dr. Sellers, and it was therefore considered prudent to adopt this program for the commencement of operations.

[1] Charter amendment of May 12, 1892, restricted water use to 200,000 "effective" horse-power.

It was recognized by all persons in interest that there were no precedents to follow and that the special problems at Niagara were only to be worked out practically and commercially by the aid of the most advanced developments of several branches of engineering, operating in close accord. Because of their novelty, every detail should have deliberate consideration from all possible points of view, and much time should be provided for this study. New designs and important inventions or discoveries were necessary. The experiences of others, particularly those of the ingenieur-constructeurs of Switzerland, where water-power is the chief product of the country, were to be sought for guidance in preparing plans at Niagara. There were various forms of power transmission in use abroad to be studied, especially the electrical methods that were then receiving much attention from scientists and engineers.

It was not deemed advisable, however, to await the solution of all these problems before proceeding with the work. Whatever forms of development and transmission might be adopted, they all would require the facilities of a water-inlet and a water discharge, and therefore these, as a hydraulic system, were prime necessities. As much time would be required for preparation, surveys, geological examinations, study of surface conditions, negotiations for rights and privileges, development of tunnel and inlet designs, etc., it was determined to proceed with the enterprise, provide the money estimated as necessary for the construction of the first section of the project, and make definite arrangements to secure complete information as to the state of the arts of hydraulic development of power and various methods for its transformation and utilization.

CAPITAL SUBSCRIBED FOR THE INAUGURATION OF THE ENTERPRISE

Action was taken in accordance with these views on January 16, 1890. A syndicate subscription was invited and $2,630,000 was received, payable in cash as required for construction purposes. The details of these financial operations will be found in subsequent chapters.

At a meeting of the "money subscribers," held February 6, 1890, after consideration of the reports of their engineers, it was resolved that:

> The Cataract Construction Company be and it is hereby authorized and requested now to proceed to the preparation, execution and performance of a contract with The Niagara Falls Power Company, such as is contemplated in the agreement (syndicate subscription) of January 17, 1890.

The president of the company, Mr. Adams, undertook the foreign consultations and investigations of scientific and engineering character and the chief engineer, Dr. Sellers, proceeded with the preparations for construction on the

preliminary plan proposed, and organized an engineering staff for his assistance. The form, size, location, grade and details of construction of the tunnel were to be determined, specifications prepared, and contracts negotiated.

Accurate surveys of the land with the view of possible purchase, and of the lands under water with riparian rights, were ordered prepared under the general direction of John Bogart, the state engineer.

The statistics of the relative number of employees, horse-power and acreage used in various industries established in New England, New York and vicinity, prompted the plan to purchase about 1000 acres in addition to the 550 acres already under control.

The raw materials to be used and the product of their manufacture required convenient and prompt transportation. To facilitate this, with competitive freight rates, "in transit" or otherwise, the larger portion of these 1000 acres for purchase were designated near the railways of the New York Central and the Erie Railroad companies, upon which lands (166 acres) the Niagara Junction Railroad would be constructed by the cataract company to assure these important commercial advantages for the new industrial community.

Certain lands (368 acres) were selected for the development of the residential village of Echota, subsequently constructed by The Cataract Construction Company, near the center of the large acreage subsequently purchased, that would be central to the industrial growth, and sufficient for extensions as the populations increased.

The system for the supply of potable water to the people of the town of Niagara Falls was insufficient for increase of population and the water was not satisfactory in purity. Plans were made to overcome these unfavorable conditions, and the stock, property and assets of the Niagara Falls Water-Works, the local company, were acquired in January, 1890, and provision made for the extension of its franchise and system and the purification of its supply.

Nearly all the rights-of-way for the discharge tunnel and the inlet-canal were acquired at this time. To assure continuity of service the recommendation of the engineers that the right-of-way for a second discharge tunnel should be acquired was adopted, and negotiations therefor were actively pushed and successfully concluded.

The extension of the trolley line to the proposed new village and the industrial plants was advocated and assured.

The harnessing of the waters of Niagara had at last been undertaken with the support of adequate capital, and the great enterprise was well under way.

EVOLUTION OF THE CENTRAL POWER STATION PLAN

1890

Chapter IX

While prosecuting these investigations I received an impression that the method we had planned (direct driving of mills by individual wheels) and were on the point of carrying out was a mistake. . . . I came to the conclusion that our true way possibly might be to build this tunnel and develop the whole power in this one central station, transmitting the power to different places.

EDWARD DEAN ADAMS
BROWN'S HOTEL
JUNE 18, 1890

EVOLUTION OF THE CENTRAL POWER STATION PLAN

1890

CHAPTER IX

THE LAUNCHING OF THE PROJECT

THE subscription, in January, 1890, of abundant funds for initial construction marked the transition from investigation to determine whether the tunnel project for power development at Niagara should be undertaken or not, to the period of constructive planning.

An outstanding result of the preliminary investigation was the revelation that there were no hydraulic power developments in existence, which would serve as examples to be followed in the Niagara undertaking. The old mill-over-the-wheel-pit plan would have involved prohibitive construction costs for excavating canals and shafts and tunnels in hard rock, and it would not deliver the power where and in amounts as it was wanted.

New methods were called for, power was to be produced on an unprecedented scale; there should be fewer canals and fewer water-wheels than were originally proposed; the wheels should be larger; there should be means for distributing power locally over a few hundred yards, or possibly a mile or two, and there should be means for transmitting power to Buffalo. But nothing in existence was adequate to accomplish these results.

There was confidence that these problems could be solved and it had been determined to proceed with the undertaking as a turbine development, by means of a short inlet and the shortest possible tail-race tunnel.

As desirable adjuncts to this plan, the right-of-way for an additional tunnel had been secured; a comparatively large area of land had been purchased, and various public utilities had been projected, that were essential to the residence and employment of what would constitute an important increase in the population of the community.

A special charter of The Niagara Falls Power Company had been secured, that had been issued by the State of New York to the Niagara River Hydraulic Tunnel, Power and Sewer Company,[1] as authority for and encouragement of the Niagara development.

A satisfactory charter of The Cataract Construction Company had been received from the State of New Jersey for the construction of works of improvement. Other charters and franchises were in process of acquisition.

Capital had been subscribed for an amount, $2,630,000, considered ample for the first section, or unit, of the hydraulic system, as well as for lands and their improvement.

[1] Name changed in 1889 to The Niagara Falls Power Company.

An engineering organization had been formulated, and preparation made for surveys, designs, plans and construction.

Central stations or power-houses were the preferred plans for development of power, provided an adequate system of power distribution could be found, either by cable drive, compressed air, water under pressure, or by electric currents.

The primary turbine units, it was believed, should be unusually large and their complementary machines, whether pumps, compressors or generators, should be mounted on the same rotating shaft so as to constitute a unit of power, developed at the foot and distributed at the top of a single column.

The immediate problem was to determine the form, size, location, grade and details of construction of the tunnel. These matters were taken up by the board of engineers of the company for the purpose of preparing specifications and negotiating contracts for the commencement of the important work of rock excavation for tunnels and inlet.

INVESTIGATION OF HYDRAULIC MACHINERY AND POWER TRANSMISSION IN EUROPE

While these preliminaries were being studied and plans developed at Niagara, the president of The Cataract Construction Company was in Europe, where he arrived in February, 1890, in quest of information as to the state of the science of power development and the art of its transmission. Anticipating that questions would arise regarding electrical transmission, particularly as to the use of direct or alternating current, he sold, prior to departure, his shares and resigned his directorship in the Edison Electric Illuminating Company of New York, in order to remove all question of personal interest, which might restrict the freedom with which information might otherwise be supplied.

There were three distinct lines of information inviting research; first, by reading technical publications, second, by correspondence with scientists and engineers; and last, by personal conferences with the ingenieur-constructeurs of France and Switzerland.

Several months were devoted to the collection of books, pamphlets, journals, the reports and proceedings of engineering societies, photographs and plans, all of which were carefully studied and their appropriate suggestions and statements noted for reference in case of need.

Switzerland, an industrial country, dependent, through lack of fuel, upon its never-failing waterfalls, had made hydraulics and mechanics special features of its educational system and had developed leaders of those sciences

and masters of those arts. At that period, they had won international recognition and could point with pride to engineering works abroad as well as at home, in evidence of their skill and experience. Therefore it was to Switzerland and its engineers that special attention was given in the first communications regarding prime movers.

To the query, "What books have you published about water-wheels?", it was answered, "A few books only, but we have built many turbines for ourselves as well as others," explaining, "this is natural, because water-power and scenery are our national resources, and turbines and hotels represent some of our most successful industries." Upon the suggestion of utilizing Niagara Falls, the Swiss manufacturers promptly manifested sympathetic interest. Their mountains were grand and their falls were numerous and beautiful, but they could not be compared with the majesty and power of Niagara, that they believed Swiss turbines should control.

A collection of Swiss trade circulars, carefully prepared and fully illustrated, many being in fact elaborate treatises upon turbines, pumps, compressors and other departments of mechanics, was soon acquired and eagerly studied.

The names of the most prominent and experienced ingenieur-constructeurs in Switzerland were obtained through assistance of the consulates of the United States at Geneva and Zurich. Subsequent correspondence brought records of experience and current work and led to personal visits and conferences. Among such correspondents, several of whose works and installations were visited, were the following.

Escher, Wyss & Company, of Zurich, who had constructed about 2000 turbines of a total of 120,000 horse-power, naturally received careful attention. Among their important water-wheel installations were cited the utilization of the Rheinfall, near Schaffhausen, of the Rhone at Geneva, of the Zurich River, and of the Rhine near Rheinfelden, by 15 turbines of 1000 horse-power each, under a head of 7 metres.

Faesch and Piccard, of Geneva, had designed and constructed several hydraulic works for power transmission of particular interest, one by cable at Bellegarde, one by electricity at Oyonnax, and one by water under pressure and a hydro-electric station, both at Geneva.

Another firm of importance was Theodor Bell & Cie., of Kriens, Lucerne, that had recently completed the hydro-electric station for the city of Berne for electrical lighting.

Joh. Jacob Reiter & Company, of Winterthur, were recognized as among the long-established and successful makers of turbines, whose co-operation

was sought in preparation for a scientific commission to consider the hydraulic question.

The Machine Works (Maschinenfabrik) of Oerlikon, near Zurich, of which Chas. E. L. Brown was then electrical director, was awarded the only Grand Prix for dynamos at the Paris Exhibition of 1889, in competition with several American exhibitors of electrical machinery. It was stated that within a few years they had made a total of more than 20,000 horse-power of electrical machinery, including motors of 400 horse-power and generators (for the production of aluminum) of 600 horse-power, which were reported to be the largest in the world. Generators of about 75 horse-power, aggregating 800 horse-power, were being supplied for hydraulic power stations in Chile for supplying power by direct current a distance of several kilometers for the drilling of tunnels in the construction of the trans-Andine Railway. Alternating-current apparatus for transmitting current considerable distances, principally for lighting, was an important feature of the work at Oerlikon, but of particular interest was the project for the transmission of several hundred horse-power for more than a hundred miles for the Frankfort Exhibition to be held the following year.

Among power transmissions by hydro-electric methods that were visited were those at Charminet, on the Ain River, 7½ kilometers to Oyonnax, where the great advantage of electrical power was seen in the facility of its subdivision for small industries requiring only from two to three horse-power. This was designed and constructed by Swiss engineers.

Domène, Isere, was also visited, about 5 kilometers from a water source, difficult of access, and practically inaccessible in winter. This plant of 200 effective horse-power was designed by A. Hillairet, a French engineer, of Paris, for the operation of the Chevrant Paper Mill, and was considered in all respects a most interesting and successful project. Power was transmitted by a direct current of 70 amperes, the average voltage being 2850.

There were a number of other, smaller hydro-electric power transmission plants in Switzerland, then in operation, several of which were installed to replace rope or cable transmissions, requiring renewal, or the substitution of electric service to assure continuity of power that was not obtained by the telo-dynamic method of transmission.

AN ELECTRIC POWER PIONEER IN FRANCE

In France, hydro-electric questions were receiving more attention in electric than in hydraulic studies. Foremost among the early workers was Marcel Deprez. The progressive historical steps which he had taken in the development of direct-current power transmission is summarized in a letter to

Mr. Adams, clearly written on note paper by his own hand. The letter follows:

(Translation)

Friday, May 23, 1890

Monsieur

Answering the letter that you have been good enough to write me, asking for the names of the publishers of my works on electricity, I beg to say that I have not written any systematic work dealing with that science.

My works have been along two lines:

1. Theoretical research work into the transmission of long-distance power, which appeared in the Proceedings of the Academy of Science since 1880, and also in the *Journal de la Lumière Elèctrique* from 1880 to 1886 and were reprinted in the scientific journals of the two hemispheres, where they gave rise to most varied and contradictory discussion and comment.

2. My experiments by which I tried to test the correctness of my theories, being in chronological order:

Munich experiment, in September, 1882. Power transmission for a distance of 57 kilometers, by an iron wire, 4½ millimeters in diameter.

Experiment at "Chemin de Fer du Nord" shops, February and March, 1883.

Experimental line between Vizille and Grenoble, distance 14 kilometers; copper wire of 2 millimeters diameter. Power received 7 horse-power; efficiency 48 to 60 per cent.

Experiment which took place in 1886, between Creil and Paris. Distance 56 kilometers; diameter of copper wire 5 millimeters. Power received 52 horse-power. At the final test there was received 80 horse-power with the electromotive force at Creil reaching 9300 volts. Efficiency 45 per cent.

All these experiments were checked by an Official Commission whose full reports were published in the Proceedings of the Academy of Science (excepting that of Grenoble-Vizille), and in practically all the scientific journals of the world. These latter, however, often gave inaccurate reports. The Official Commissions were composed of the most eminent authorities of our country.

You will find all possible information covering the two first experiments (Munich and "Chemin de Fer du Nord") in a little volume published by Bernard-Tignol, 45 Quai des Grands Augustins, Paris, entitled *Le Transport de la Force* by Japing.

As regards the experiments at Grenoble and Creil, the reports covering those were printed separately, and I have the honor of forwarding you a copy hereof.

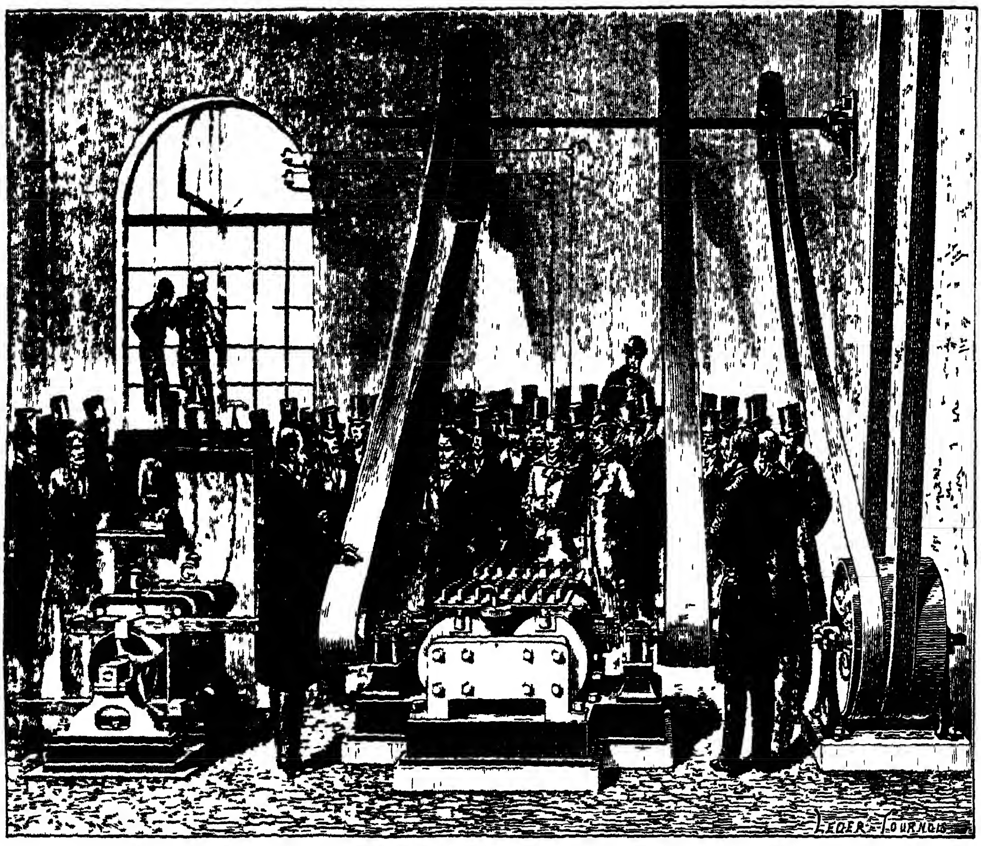
Finally, in 1889, I installed at Bourganeuf (Department of the Creuse, France) a power transmission which has been operating for a year and is showing remarkable results, by the strength of the installation, by the extremely small number of operatives (one man at the turbine that drives the generator, and one man, with an assistant, at the receiving end of the line) which meets all needs, and, finally, by the absolute regularity of operation. The distance is 15 kilometers, the wire 5 millimeters. I published complete details of this installation in *La Lumière Elèctrique*, September, 1889.

I shall publish shortly a description and a sketch of the 500 horse-power unit that I had constructed for the Exposition of 1889 and that I have been unable to sell as yet, by reason of its power being excessive for the ordinary factories.

Si vous desirer d'autres renseignements je me ferai plaisir de vous le donner.

Veuillez agreer Monsieur l'assurance de mes parfaits consideration.

Marcel Deprez



Marcel Deprez Explaining in 1883 His System of Electrical Transmission of Power from Paris, 8 Kilometers, to the Northern Railway Shops

Resumé of the Marcel Deprez demonstrations of power transmission referred to in his letter and the accompanying text.

Dates	*Locations*	*Distances in Kilometers*
1881	Paris Exposition	Local
1882	Munich Experiments	57
1883	Shops of the Northern Railway of France	8
1884	Grenoble-Vizille	14
1886	Creil-Paris	56
1889	Bourganeuf Transmission	15

In 1881, in the Palace of Industry at the Paris Exposition, M. Deprez showed his electrical work for the first time. The power generated was to drive 27 different pieces of apparatus including sewing machines, etc. Each of these machines had its own little electric motor.

One of M. Deprez's first theoretical pieces of work was published in the August 24, 1881, issue of *La Lumière Elèctrique* and consisted in showing that with the existing machines, with the aid of a transformation, one could effect long-distance transmission. The calculations were based, it was stated, upon experiments made by English engineers at Chatham.

It was at the beginning of the year 1882 that the committee having charge of the organization of the electrical exposition at Munich communicated with M. Deprez. Making use of an existing telegraph line, M. Deprez effected a transmission of 57 kilometers. It seems that the committee at Munich had not much confidence in the success of the experiment, but when at a given signal the machines got into motion, great applause greeted the feat. A series of accidents, due to the fact that the machines had been built for laboratory instead of for practical purposes, caused the machines to be put out of order after eight days of satisfactory performance.

In continuation of experiments in transmission, an electric machine was built about the month of January, 1883. After searching for a convenient place to try out this machine, the Compagnie du Nord placed a transmission line at the disposal of the experimenters. It was here, in the shops of the Northern Railway of France that a transmission of 8 kilometers was obtained in 1883.

The special committee appointed had not the means of judging the economic value or the future possibilities of the results obtained, but proposed to the Academy of Sciences that Marcel Deprez be congratulated on the important progress which he had made.

The *Journal de la Lumière Elèctrique* of January 5, 1884, refers to power transmission by Marcel Deprez, showing that his theory of the transmission of power was verified by his experimentation, as well as by official reports.

The experimental transmission of electric power by continuous current from Creil to Paris was made by M. Deprez in 1886. A railway locomotive supplied the primary power for the electric machine that generated 116 horsepower and sent the current 56 kilometers (35 miles) to an electric motor at the railway station of La Chapelle, in Paris. A scientific commission,[1] composed of engineers and members of the Academy of Sciences, was selected, by

[1] See *L'Electricien* of August 21, 1886, Report of Commission to L'Academie des Sciences on "Le transport de grandes forces motrices" by Marcel Deprez between Creil and Paris

request of the Messrs. Rothschild, who were financing the experiment, to report the results obtained by M. Deprez.

The current of 6200 volts was transmitted on an overhead line of silicon bronze wire of a resistance of an ordinary telegraph wire, with an efficiency of about 45 per cent. Both electric machines were of the Gramme ring type.

Although M. Deprez expected this transmission to show an efficiency of 50 per cent, and there were unexpected difficulties of faulty insulation in machines and line to overcome, the commission announced the result as remarkable and in the name of science and industry extended its hearty congratulations to M. Deprez upon the admirable results he had obtained.

The editorial review of this report by *L'Electrician* states that after waiting five years for important developments, "the Creil-Paris experiment does not show any practical results and that such results may still be awaited for a long time."

The hydro-electric transmission in 1889 of light and power from Les Jarrauds Falls on La Maulde River, 14 kilometers to the city of Bourganeuf (Creuse, France) was designed by M. Deprez and may briefly be described from his detailed account.[1]

Hydraulic head—31 meters.

Turbine of horizontal axis and 130 horse-power connected by belt with the dynamo.

Speed of turbine—150 revolutions per minute.

Speed of generator—650 revolutions per minute.

Voltage of generator—5 to $5\frac{1}{2}$ volts at speed of one revolution per minute.

Generator of 100 horse-power capacity.

The line wire was 5 millimeters in diameter of bar silicon bronze and carried on posts with porcelain insulators similar to an ordinary telegraph line; with 23 ohms resistance for the 14 kilometers.

The motor was identical with the generator. The motor drove two lighting machines of the Gramme type that produced 130 volts and 250 amperes each.

These experiences of M. Deprez are those of a pioneer in power transmission, and to him should be accorded high honor. But in magnitude they were trivial compared with the Niagara project and the method of transmission by direct current at constant value was not suited to the requirements of a large power system.

[1] See *La Lumière Electrique*, September 21, 1889.

SUMMARY OF POWER CONDITIONS IN EUROPE

The largest hydraulic and electric machines in practical use at that period, 1890, anywhere in the world according to their makers, were the

1000 horse-power generator, direct current, for lighting, constructed by Siemens and Halske of Berlin.

600 horse-power generator, direct current, designed by Chas. E. L. Brown of the Oerlikon Works, Switzerland, for aluminum works.

1000 horse-power single-phase alternator, direct connected, constructed by Ganz & Company, of Budapest.

14 turbines of 1000 horse-power each, made by Escher, Wyss & Company, of Zurich, for their installation on the Rhine near Rheinfelden.

The electrical transmissions of power which seemed most notable and significant as the result of the European visits were the following:

Marcel Deprez, the transmission of 82 horse-power, Bourganeuf to Paris, 15 kilometers, direct current, 1889.

Oerlikon Works, the transmission of electric power from 12 generators of about 70 horse-power each for drilling tunnels on the trans-Andine Railway in Chile, a few miles, direct current, 1891.

Oerlikon Works, the transmission of 300 horse-power, 108 miles, by alternating current, from Lauffen to Frankfort, proposed in 1890 by C. E. L Brown for the exposition the following year.

It appeared to the American seeker after information that the greatest progress in power transmission was to be found on the continent where there were numerous examples of power transmission by direct current and where the possibilities of the use of alternating current for long-distance transmission for power as well as lighting were not only recognized but were being actively undertaken on a magnificent scale. There was a progressive attitude among engineers and manufacturers of the highest responsibility, which gave promise of continuing the development in which succeeding years produced greater achievement in amount of power and distance of transmission.

Other methods of transmission of power were in evidence and had their strenuous advocates. Rope or cable transmissions were numerous in many countries. They were limited to about 3 miles in effective use, were irregular in power delivery, and their users were commencing, when in need of repair or replacement, to change that system for electric transmission.

Power transmissions and distributions by compressed air or water were few, and those of comparative importance in power and in distance of transmission in England, France and Switzerland, had not, with few exceptions, shown sufficient financial success to attract additional capital.

A very careful survey of this situation after persistent research, gave convincing evidence that the power situation was undergoing a distinct change in methods; from fuels of increasing costs and irregular deliveries, to nature's provision of water, that was wasted continually and in many cases required only conduct to storage for use as desired. Practical methods of economical transmission of mechanical power derived from falling water gave at once a market for almost every waterfall, varying in value according to the cost of utilization and the proximity of users.

It thus became apparent that the cataract company was duly warranted in proceeding with its plans for a hydraulic development of power, and that the facilities of Switzerland and France were ample for manufacture of the largest units desired. In no phase of the power problem was there greater interest nor was the situation progressing more rapidly than in the solution of methods of transmission and distribution. Hence it seemed that it might be possible to concentrate still further than was at first proposed the generating apparatus for the production of the power at Niagara Falls, and depend more upon the distributing system. If this were feasible, the tunnel for discharging water from the wheel-pit need not be extended beyond the single power-house location at which all the power might be developed.

PROVISIONS FOR SCIENTIFIC WORLD-WIDE STUDIES

The situation called for careful study and investigation; changes in methods of producing and conveying and using power were taking place which gave promise of great extension and development; expert service was required; there was need of attracting the thought of the best scientists, engineers and manufacturers to the Niagara problem that they might evolve new methods and new machinery to meet unprecedented conditions.

Two conclusions were reached, namely, that one power-house might suffice and the tunnel might be shorter than had been proposed, and second, that a scientific investigation by the representative scientists of the countries most concerned should be made; these prompted President Adams on May 11, 1890, to send a cable message from Paris to Vice-president Francis Lynde Stetson, of the cataract company's New York office, stating that

After careful investigation conclude practise here far ahead ours. Recommend defer execution construction contracts.

Considering inviting American, English, French, Swiss houses to submit competitive preliminary schemes to commission composed of Sellers, Edison and English, French

and Swiss engineers, one each. Important Sellers meet me London immediately. Cable views directors.

The cable brought the answer:

Directors present approve your plan. Edison impossible. Sellers sails Saturday with all papers

With this encouragement, the development of a scientific symposium on the utilization of the waters of Niagara moved on apace.

Many previous visits to the three foreign countries specially interested in this matter, and numerous acquaintances therein of financiers and engineers of influence and information, facilitated inquiries in France, Switzerland and England regarding machine constructors of highest rank in responsibility, and as to scientists desirable and available to represent their nationals.

After presenting this program tentatively in Paris to various circles of French interests and to visiting engineers from Switzerland, President Adams went to London, where he consulted various helpful interests and introduced the subject to Sir William Thomson, with the suggestion that should he be disposed to accept the chairmanship of an International Niagara Commission, it would probably be offered him by the directors of the cataract company. Various names were submitted to him and suggested by him as desirable associate commissioners. Details of organization and procedure were considered, and a further conference was arranged for a call with Dr. Coleman Sellers In the interview at Cambridge, June 2, Sir William expressed his willingness to serve as previously suggested.

After a week of conferences and exchange of views, Dr Sellers and President Adams went to Switzerland, where they visited together the works previously inspected by the latter in May and conferred with the representatives of the principal Swiss engineering firms respecting the proposed commission under the chairmanship of Sir William Thomson.

Assurances were received from those invited that they would submit projects and that they approved of the engineer suggested, Col. Theo. Turrettini, as the representative of Swiss industries on the commission.

At the close of this tour through industrial Switzerland with its opportunities of considering the problems at Niagara with the many engineers in conferences, and after a review of the whole situation with the chief engineer of the cataract company, its president sent these cable messages to Mr. Stetson, from

Geneva, June 8, 1890

Am convinced International Commission best course. Sir William Thomson will act as president. Consider convenience Stetson replacing me abroad during July August sailing after my return.

Paris, June 10, 1890. No. 1

Sellers concurs decided opinion abandon all tunnel beyond 8000 feet, also all canals except short surface inlet, adopt one central station for entire power capacity tunnel dimensions proposed, also agree International Commission only plan secure best methods, recommend pushing commission rapidly.

Paris, June 10, 1890. No. 2

Much valuable time saved if Stetson meet me London by twenty-fourth. Have arranged conditioned upon directors' approval, International Niagara Commission, President Sir William Thomson, Sellers, Mascart, Membre Institute, Professeur College France, Turrettini, Mayor Geneva. Headquarters sessions London. Principal engineers Europe promise compete. Cost including prizes about thirty-five thousand.

To these messages replies were received by President Adams stating

Directors approve proposed commission and expenditure

and on June 24, after receiving a draft of the invitation to be issued from the headquarters of the commission in London and from the office of the company in New York, the cable announced

Directors approve invitation.

The records of the meeting of the directors in New York on that date were as follows:

Additional letters and cablegrams from President Adams and Dr Sellers were read and the action proposed to be taken by Mr. Adams in relation to the International Commission and invitation of competitive plans and bids were approved and authority given to issue similar invitation to selected parties in this country.

A fortunate opportunity then occurred for presenting the plans to the "money subscribers" who were in London. The minutes of the meeting follow:

REPORT OF PROGRESS AND FIRST FORMAL PROPOSAL
OF CENTRAL POWER STATION PLAN

MINUTES OF MEETING OF SYNDICATE SUBSCRIBERS JUNE 18, 1890,
AT BROWN'S HOTEL,[1] LONDON, TO CONSIDER PROPOSALS FOR AN
INTERNATIONAL NIAGARA COMMISSION FOR THE GUIDANCE
OF THE SYNDICATE SUBSCRIBERS IN THEIR PLANS
FOR THE DEVELOPMENT OF NIAGARA POWER

On the invitation of Mr. Adams, a meeting was held at his apartment in Brown's Hotel, London, Wednesday, June 18, 1890, to which were invited all the parties interested in the Niagara syndicate in London, viz: Dr. Coleman Sellers; Vice-president Edward A. Wickes; A. J. Forbes-Leith;

[1] See Chapter XXIX, Volume II, for details of memorial established in Brown's Hotel.

Morris K. Jesup; Alexander Hargreaves Brown, M.P.; Capt. Francis Pavy; C. C. MacRae; Louis Floersheim; Louis Schott; Henry Oppenheim; Lord Rothschild; Robert R. Symon; W. Brodrick Cloete; Frederick Nettlefold; Ernest Cassel; Frederick W. Whitridge.

Of these the following named gentlemen were present: Dr. Coleman Sellers; Edward A. Wickes; A. J. Forbes-Leith; C. C. MacRae; Robert R. Symon; W. Brodrick Cloete; Frederick Nettlefold.

Mr. Adams stated:

Since my arrival in this country, I have been giving a great deal of attention to this subject and as I proceeded with my investigations, my interest increased constantly and finally I think I am an enthusiast on the subject. About two months ago, while prosecuting these investigations, I received an impression that the method we had planned and were on the point of carrying out, was a mistake, but I was not willing to come to that conclusion without the assistance of some of our consulting engineers, so I cabled to the other side, suggesting that they should stop work so far as it affected the prolongation of the tunnel and the adoption of the plans. In order that you may understand clearly what I mean, I will indicate, by reference to the maps, the course pursued. The map I now show you is a government map of the Niagara River, giving the position of the town of Niagara and the falls, and indicating the direction of the flow of the river. It was the intention originally, to underrun the land of the company by a tunnel that passed underneath the town of Niagara and emptied into the lower river, this tunnel being one of sufficient capacity, in length of about 7300 feet, to meet the requirements of the development of about 120,000 horse-power, but it was not the intention to utilize that power immediately at the end of tunnel of the length given, but as the power was disposed of, to continue the tunnel to a total length of 13,000 feet In order to supply the various mill-sites which might be scattered over this land extending several miles along the river, canals would be brought in at intervals Such are indicated on this smaller map. These canals would overlie the tunnel and from such canals which were wide at their mouth but tapered towards their end, minor canals would be led to various wheel-pits which in turn would discharge into the tunnel. All this pointed to so great a cost, that it seemed to me advisable to pause before proceeding with such an investment, and to take advantage of what I had noticed was being done everywhere in Europe, to concentrate the source of power at some one place and from that one source of power to transmit it to the factories either upon our own land or the land adjacent thereto, or in fact to a still greater distance to Tonawanda or Buffalo or anywhere within the radius of the possible transportation of power economically. By this means, I satisfied myself that of the various methods of transmitting power, some one, or more might be adopted that would enable the mill owners to be as perfectly independent as if they each had their own wheel beneath their mill as originally planned. In other words, that the power being carried by electricity could be transmitted to the mill and there operate electric motors that would be as efficient as the best steam engines. The same obtains in reference to other modes of transmission, whether by rapidly running cables, by hydraulic power or by compressed air. At all events, I came to the conclusion that I

was right in the idea that the application of modern science on the continent of Europe had changed the whole methods of hydraulic working and transmission of power, and that our true way possibly might be to build this tunnel and develop the whole in this one central station, transmitting the power, as I have already indicated, to different places. Upon receipt of my dispatch, I was glad to find by the reply that no contracts had yet been made for the excavation of these canals. I therefore asked that Dr. Sellers should come over and assist me in determining this question. He came very promptly; I met him here in London, where we spent a week or ten days and then proceeded to the continent from whence we have just returned after a tour in Switzerland and France where we have been in consultation with all the engineers who are practical men, and I will now ask him to explain to you the various steps by which his judgment is now, I believe, in entire accord with my own, as to the best course.

He then introduced Dr. Sellers, who gave a lengthy explanation of the changes proposed, the reasons therefor and the economies expected. Among other things, he called attention to the enormous cost of the one canal which had been designed, primarily, for the utilization of 20,000 horse-power and ultimately, by a still further extension of the tunnel, to a total of only 48,000 horse-power. He stated that so far as he had been able to judge, it seemed to him that the cost of this immense excavation, which was a small river in itself, would go very far towards developing the whole of the 120,000 horse-power and inasmuch as the shortening of the tunnel would also heighten the available fall, that could be done by the wheels increasing that fall from 110 to 140 feet, thus diminishing the total volume of water required per horse-power; that the tunnel as designed would be sufficient to fully satisfy at least 130,000 horse-power developed at one central location; that it was scarcely worth while to call attention to the still greater saving of doing away with these many other canals which would have to be added to the first one to complete the total planned; that the more he looked into this scheme which was proposed by Mr. Adams, the more thoroughly he was convinced of its correctness, and that he had found his labor in this investigation very much diminished by the very thorough manner in which Mr. Adams had accumulated the facts that pointed so conclusively towards this method of procedure.

Following Dr. Sellers remarks Mr. Adams explained his plan for an International Commission, drawing from the gentlemen present a quite strong expression of opinion as to the economy with which he had effected so brilliant a combination of talent as was expressed in the union of the gentlemen representing England, France and Switzerland.

An animated discussion of the subject by the gentlemen present, who asked many questions and seemed well satisfied with the replies, was unanimous in approval of the modification of the original plans and also of the commission as proposed.

The meeting was in session about two hours, and from the notes of remarks, taken by Mr. F. Rose,[1] the preceding summary has been made.

A full explanation of the changes in the plan and the commission proposed, was sent by Mr. Adams from Paris, June 12, 1890, to J. Pierpont Morgan, Grand Hotel, Aix-les-Bains, who telegraphed his reply to Mr. Adams as follows:

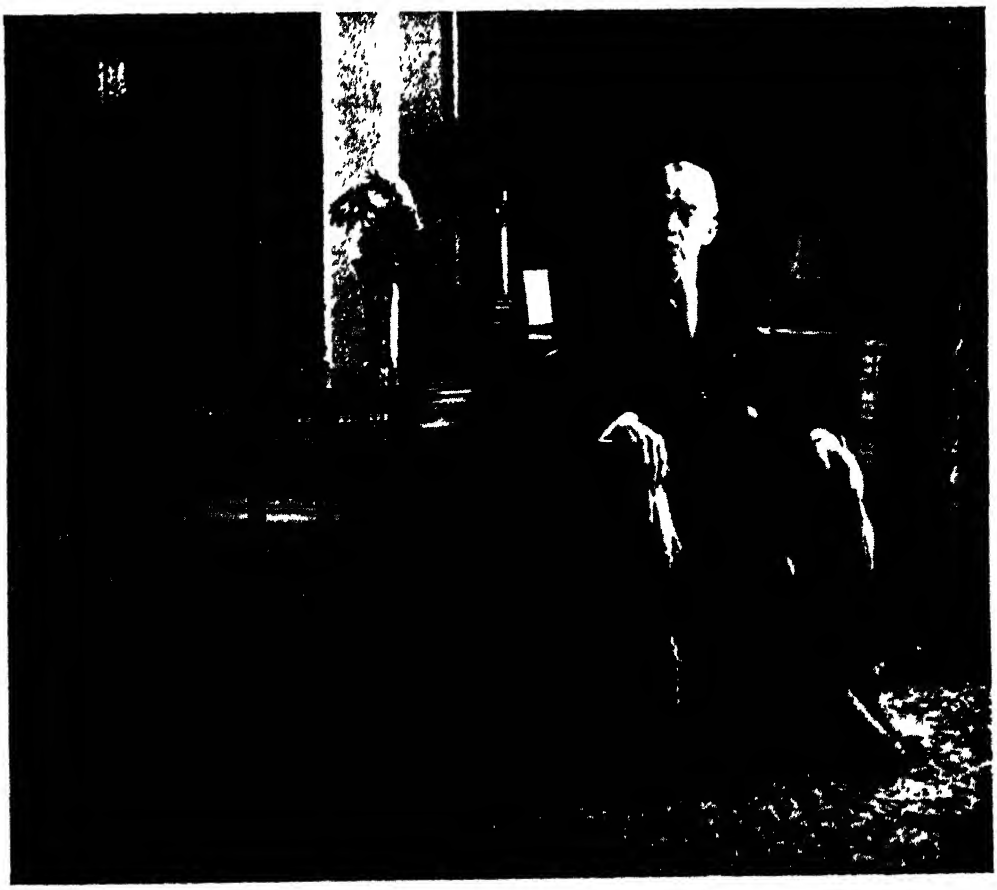
Aix-les-Bains, June 20, 1890

Edward D. Adams, Brown's Hotel, Dover Street, London.

As well as can judge, your whole plan meets my entire approval.

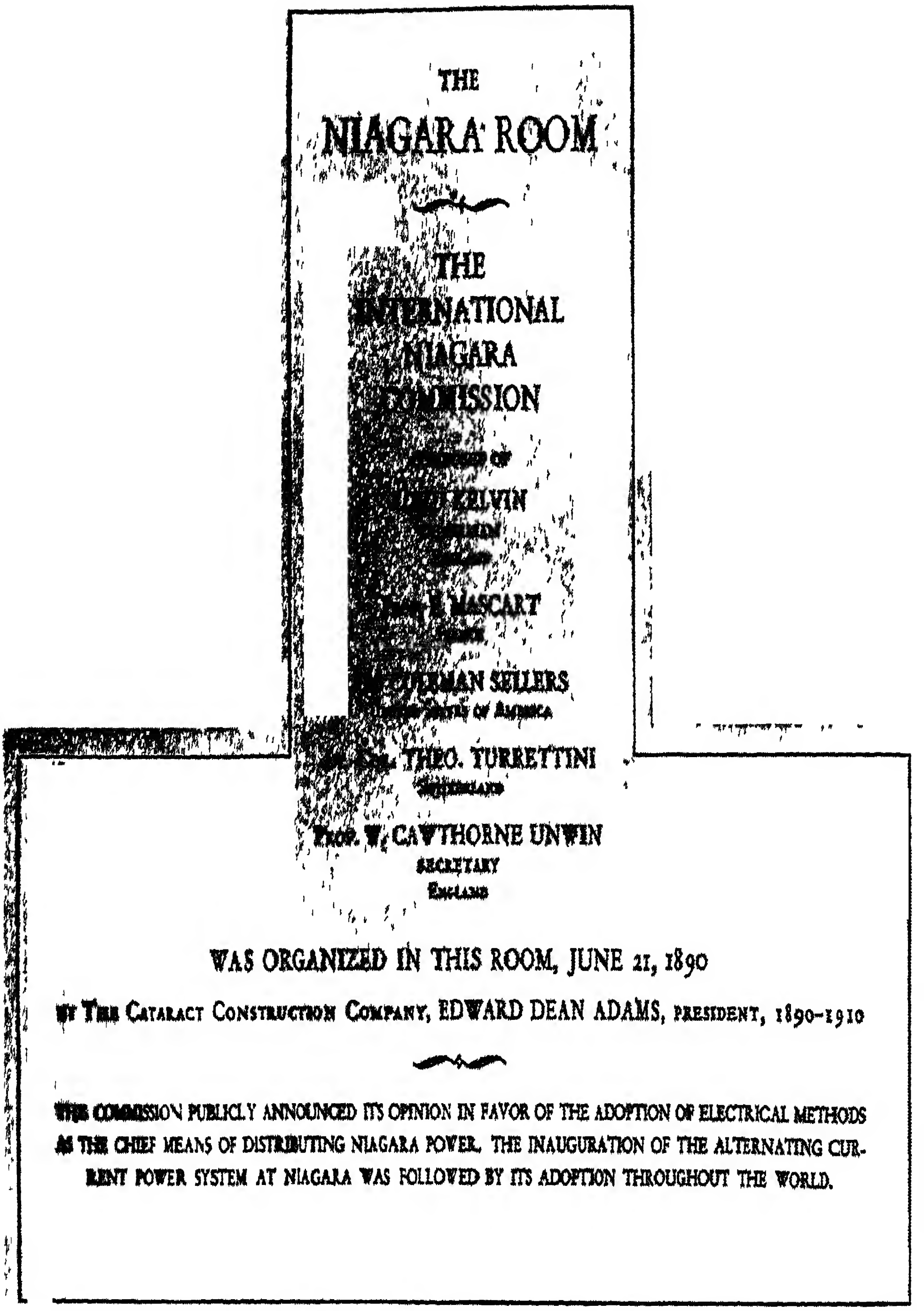
Morgan.

The further evolution of the plans for the power station and transmission system will be found in subsequent chapters in Volume Two, relating to the construction and operation of the hydraulic and the electric systems.



Author of *Niagara Power*, Sole Surviving Pioneer Director of The Cataract Construction Company in Niagara Room, Brown's Hotel, London, August, 1926

[1] A secretarial expert who served the commission in London, and later accepted an appointment with the company in Niagara and New York.



Tablet on Inside of Entrance Door of the Niagara Room, Brown's Hotel, Dover Street, London, Erected 1926, in Commemoration of the Organization of the International Niagara Commission

THE

INTERNATIONAL NIAGARA COMMISSION

1890–1891

Chapter X

THE INTERNATIONAL NIAGARA COMMISSION

1890—London—1891

3—SIR WILLIAM THOMSON, LL D, F R S
President

1—PROF E MASCART

4—DR. COLEMAN SELLERS

2—PROF W. C UNWIN, *Secretary*

5—COL. THEO TURRETTINI

THE INTERNATIONAL NIAGARA COMMISSION

CHAPTER X

ORGANIZATION AND EARLY ACTIVITIES

THE purpose of the International Niagara Commission was to conduct a scientific symposium on the development of power at Niagara Falls, which would attract the best scientific and engineering knowledge and experience of those most competent to be found in the nations of the world.

The Cataract Construction Company issued June 25, 1890, a letter of invitation from the temporary office of the commission at London, and from the administration offices of the company in New York. A letter of eleven pages enclosed a list of its accompanying documents. As the substance of this communication is contained in the comprehensive and lucid report of the secretary of the commission which will be found in full in Appendix E, this volume, the first and last pages only of the letter are reproduced here.

The plan in brief outline was designed to ascertain the best system for the Niagara enterprise in the opinion of the highest available scientific authorities.

The members of the commission were five in number, two from England and one each from France, Switzerland and United States, and may be described as follows:

Sir William Thomson, LL.D., F.R.S., President of Commission, The University, *Glasgow*.

Coleman Sellers, E.D., M. INST. C. E., etc., *Philadelphia*.

Professor Engineering Practise, Stevens Institute of Technology, Hoboken, New Jersey.

Professor of Mechanics, Franklin Institute of State of Pennsylvania.

E. Mascart, Membre de l'Institut, *Paris*.

Professeur au Collège de France.

Directeur du Bureau Central Météorologique.

Theodore Turrettini, Ingénieur, *Geneva*.

Lieutenant-Colonel d'Artillerie.

Président de la Ville de Génève.

Directeur des Travaux d'Utilisation des Forces Motrices du Rhône à Génève.

Directeur de la Société Génevoise d'Instruments de Physique.

Wm. Cawthorne Unwin, F.R.S., M. INST. C.E., *London.*
Secretary of Commission.
Professor of Engineering at the Central Institute of the City Guilds of London.

At a meeting of organization when all parties were present, Sir William Thomson was chosen president and Professor Unwin, secretary.

At the first meeting of the commission at his apartment in Brown's Hotel, London, on June 21, Mr. Adams presented for consideration the draft of a letter of invitation and explained the various plans and maps that it was intended should accompany the invitation. He stated the necessity for his departure for New York on June 25, and that he would be represented, during his absence, at first by Edward A. Wickes, then in London, and later by Francis Lynde Stetson, both vice-presidents, who would soon come from America with an associated official of The Cataract Construction Company. Mr. Adams asked that these gentlemen be invited to attend the different meetings of the commission, not as members, but as listeners and spectators, that they might thereby be informed of the progress of its activities and make the acquaintance of the participants and their expert assistants.

At the second meeting of the commission, the letter of invitation was again revised and the list of those to whom the invitation was to be sent, was prepared, each member of the commission suggesting the names for the country he represented. On June 24, the third meeting was held, at which the final draft of the invitation, in English and French, was adopted, and the list of those to be invited was approved, including the following nationals: America, five, England, seven, France, nine, Switzerland, six, and Hungary, one, being twenty-eight in all.

THE INTERNATIONAL NIAGARA COMMISSION

LETTER OF INVITATION

THE CATARACT CONSTRUCTION COMPANY

Administration Offices, Mills Building, New York

EDWARD D ADAMS, *President*
FRANCIS LYNDE STETSON } *Vice-presidents*
EDWARD A WICKES }
GEORGE H. KENT, *Treasurer*

COLEMAN SELLERS, E.D } *Consulting Engineers*
JOHN BOGART, NEW YORK STATE ENGINEER }
CLEMENS HERSCHEL, *Hydraulic Engineer*
ALBERT H. PORTER, NIAGARA FALLS, NEW YORK, *Resident Engineer*

THE INTERNATIONAL NIAGARA COMMISSION

TELEGRAPHIC ADDRESS
"Niagara, London"

London, June 25, 1890.

Private.

The Cataract Construction Company having completed its organisation and financial arrangements in the United States of America is desirous of securing the best possible technical advice as to plans for carrying out the purpose it has in view, from the best houses at home and abroad. To this end, it offers a series of prizes to a number of carefully selected Engineers and Engineering houses or Companies of America, Great Britain, France, Switzerland, and elsewhere for the best practicable engineering scheme or project.

You are therefore invited to submit projects for the development, transmission and distribution of about 125,000 effective horse-power on the shafts of water motors at the Falls of Niagara, to the consideration of an International Niagara Commission, holding its sessions at Central Institute, Exhibition Road, London.

* * * * * - * * * * - *

For additional information application should be made in person, by mail or wire to the Secretary of the Commission, or if more convenient to the individual members of the Commission

In acknowledging the receipt hereof please inform me if you will enter the Competition

Respectfully yours,
Cataract Construction Company
Edward D. Adams
President.

After issuing the letter of invitation asking that projects be presented, there was much correspondence and numerous visits from those intending to participate. The headquarters of the commission were established at the Central Institute, South Kensington, Exhibition Road, London, by the courtesy of its owners, the City and Guilds of London for the advancement

[1] It is believed that all data necessary for a complete understanding of this program will be found in the four pages of the Letter of Invitation in the Appendix, where the full report of the International Niagara Commission may also be read.

of technical education. There were many conferences with the officials and engineers of the cataract company who were in London during that period. Members of the commission, with the American engineers, visited many factories and installations of power apparatus in England and on the continent while the projects were being prepared.

STATE OF THE ART OF POWER TRANSMISSION

The most serious problem in the Niagara enterprise was involved in the transmission and distribution of power. The members of the commission therefore made special inquiry as to methods of power transmission then in use, both by visits to various installations and by conferences with experts and advocates. They examined non-electrical methods and sought comparison with electrical operation, having in mind not only what was then in operation but what might be developed.

In the latter part of July, Commissioners Mascart, of France, and Turrettini, of Switzerland, made jointly a tour of inspection of the hydro-electric and other works of machine construction and operation in France and Switzerland.

Vice-president Stetson and Engineer Bogart commenced on August 22 a series of visits in Switzerland and France, ending in Paris, September 6, and going over practically the same territory covered by the previous visits of President Adams and Chief Engineer Sellers.

Personal acquaintance with many of those who were preparing plans to submit to the commission facilitated better understanding of the conditions at Niagara, and prompted an extension of the time for filing such projects to January 1, 1891.

Much time was devoted, while in Paris, to a careful examination of the compressed air system, then in operation under the direction of Victor Popp and the guidance of Prof. A. Riedler, of Berlin, an exponent of the art, and his consulting engineer.

This method of power transmission was further examined in England, at Birmingham, under the guidance of John Sturgeon, of Chester, and Professor Lupton, of Leeds. The uses of compressed air at Chester and elsewhere of less importance were also observed.

One of the largest users of compressed air in Birmingham said that he considered it the best practicable power and when asked if he thought it better than electricity answered, "Oh, I say nothing about electricity now; I use this until the coming of electricity which I believe is the great power of the future."

The electrical station at Deptford, transmitting light by alternating current to Grosvenor Gallery, London, was visited by all the company's representatives from time to time, and the views of Mr. Ferranti, its designer, were found of much interest in their relation to compressed air and alternating current at high pressure in the generation as well as in the transmission of large amounts of power to considerable distances.

Professor Rowland, of Baltimore, and Professor Riedler, of Berlin, were among those who discussed with Mr. Ferranti in London, the relative advantages of compressed air and electricity for power transmission. Professor Riedler said to Mr. Ferranti that if his statements were well founded there could be no question that electricity must prevail over compressed air.

Lord Armstrong, at that period considered the apostle of hydraulics in England, in a conference with Sir William Thomson (Lord Kelvin) who related the conditions of the Niagara project for the transmission of power and the organization of the International Niagara Commission to consider the subject, was reported to have said:

> I do not think you can look for much good to be gained by hydraulic transmission, the wonderful progress that has been made in electricity of late, would seem to me to indicate that you will have to rely almost wholly on electrical transmission.

Clemens Herschel, hydraulic engineer of the cataract company, went at its request to London, October 8, for a conference with Chief Engineer Sellers, Professor Unwin and George F. Deacon, hydraulic engineer of Liverpool, regarding various characteristics of the proposed tunnel. Several days were passed in critical examinations of all the questions involved in determining its various dimensions.

An agreement was reached unanimously and Mr. Herschel sailed for home on the 15th, ready to give precise figures in working drawings for the contract, already prepared for the construction of the tunnel.

The beginning of the tunnel at this time before the method of distributing power had been determined, and when it appeared that no existing system was adequate to the large scale operation proposed at Niagara, was considered a bold step; it involved a great risk; it was based on faith in the ability of scientific and engineering skill to solve the new problems.

Mr. Stetson departed for home October 29, having passed more than three months in England and on the continent in his search for information to guide his judgment as to what course was for the best interest of the stockholders of The Cataract Construction Company to pursue in the furtherance of its enterprise at Niagara Falls.

Dr. Sellers wrote after Mr. Stetson's departure:

I part with him with regret, missing continually his active and unwearied attention and wise direction of the business of the company. His orderly, legal mind and his administrative ability have been shown in all the correspondence and conferences that have led up to the present assured feeling that the first important steps are right.

In the latter part of November, Dr. Sellers left London for an extended tour in France and Italy for the purpose of visiting engineering works and installations not previously seen and incidentally of making the acquaintance of the engineers connected therewith.

The visit in Rome, with Prof. G. Mengarini, the electrical engineer, and the study of his Tivoli-Rome transmission project proved of great interest and profit. Professor Mengarini was a member of the commission of experts to examine, test and report on the Lauffen-Frankfort transmission of 1891. He was particularly esteemed in electrical engineering circles for his advanced work on electrolysis and alternating currents.

The Tivoli-Rome transmission is 18 miles in length. The so-called "new" falls are 334 feet high. The hydro-electric plant was built by Ganz & Company of Budapest, and was placed in operation in July, 1892. A full report regarding the Tivoli project as designed was made by Dr. Sellers.

He returned to London late in December to assist Professor Unwin in the distribution of the duplicate copies of the competition projects received by January 1, 1891 for the International Niagara Commission. A complete set of all maps and plans, as well as a copy of the memoirs, or explanatory text, was to be provided for each commissioner in order that he might have full opportunity for study prior to the assembling of the full commission for their consideration.

CONSIDERATION OF PROJECTS AND AWARD OF PRIZES AND PREMIUMS

There were fifteen European and five American competitors represented by the project received. Several projects were not entered in the competition because of failure to comply with the important conditions imposed by the terms of the Letter of Invitation.

The competitors were duly notified upon the receipt of their projects that the commission would meet to consider them on Thursday, January 29, 1891, and daily thereafter as might become necessary to decide the competition and award the prizes, and that any competitors who desired to attend the meeting could do so.

Quite a number of the competitors availed themselves of the opportunity to attend the first three sessions of the commission, the continental competitors generally being accompanied by their technical experts.

The commissioners were in full attendance, sat for about seven hours daily, for six days without a break, and reached their final conclusions on February 4, 1891.

Clemens Herschel, hydraulic engineer, and Albert H. Porter, resident engineer, were present by invitation at all sessions, and rendered valued assistance by personal explanations of local conditions at that time in Niagara, and by entertaining the foreign engineers between sessions, for which the familiarity of Mr. Herschel with French and German, which he spoke fluently in technical terms, was much appreciated.

Daily reports of the proceedings of the commission in session were made to the New York office of the company by Messrs. Herschel and Porter. Dr. Sellers presented a full report in March, to the cataract company upon his return to New York, after an absence in Europe for about nine months, solely in the interests of the company.

The formal duty for which the commission was organized was now performed by the award of prizes among the competitors. In the final conclusions there was almost entire unanimity.

> Seventeen projects were submitted by the twenty representatives of six countries: America, England, Switzerland, France, Germany, and Hungary. Three projects were rejected as irregular and fourteen projects were considered in the competition.
>
> Awards of prizes were made as follows: Four for pneumatic projects, four for electric projects. Eight prizes awarded: two to Switzerland, two to France, one to Germany and France combined, one to England, one to Hungary, and one to America.

No first prize was awarded for a combined project for hydraulic development and electrical distribution of power. There was no project which, in the opinion of the commission, could be recommended for adoption without considerable modification.

The highest prize awarded for combined projects for hydraulic development and electrical distribution of power went to Messrs. Faesch and Piccard,[2] and Cuenod, Sautter & Company, both of Geneva.

[1] List of Awards is given in Part III of the Report by Secretary Unwin Appendix E, Volume I.

[2] A contract was subsequently made with Faesch and Piccard, by which complete working drawings were made for a 5000 horse-power turbine and governor. The entire turbine installation, of ten units of 5000 horse-power each, in Power-house Number One, was manufactured in America from these same designs of Faesch and Piccard.

The first prize for projects for hydraulic development was awarded to Escher, Wyss & Company, of Zurich.[1]

No prize was awarded for system of distribution.

Premiums were awarded to all competitors who, in the opinion of the commission, complied with the terms of the Letter of Invitation.

For Combined Projects
premiums of £200 each were awarded to eight competitors.

For Hydraulic Projects for Developing Power
premiums of £100 each were awarded to four competitors.

For Projects for Distributing Power
premiums of £100 each were awarded to two competitors.

Five American projects were presented to the commission for consideration as candidates for prizes and premiums:

Brush Electric Light and Power Company of Niagara Falls, Benjamin Rhodes, Manager. Hydraulic and electric transmission of power.

Norwalk Iron Works Company of Norwalk, Connecticut, Eben Hill, president. Transmission of power by compressed air. Pelton Water Wheel Company combining for hydraulics.

Pelton Water Wheel Company of San Francisco, California.

Stillwell and Bierce Manufacturing Company of Dayton, Ohio, Turbines.

Swain Turbine and Manufacturing Company of Lowell, Massachusetts.

The projects of the Pelton Water Wheel Company and of the Norwalk Iron Works Company were the only American projects that complied with the conditions of the competition. Each of these projects received a prize of £200, and each of them a premium of £100.

The total expenditures in England, France, Switzerland, Belgium and Germany, for engineering fees, machinery and materials resulting directly

[1] Later Escher, Wyss & Company, of Zurich, designed working drawings for a 5500 horse-power turbine, from which eleven units were constructed in America as the full hydraulic equipment of Power-house Number Two.

This firm also furnished drawings for a 10,000 horse-power turbine and received an order for the manufacture of three of these machines complete, including shafting and governors, at their works in Zurich, for the Canadian power-house. Two additional turbines made in America were of this design, for which Escher, Wyss & Company made the governors of the same model as those furnished with the three machines made in Zurich.

from the International Niagara Commission, amounted to about $430,000, not including the salaries and expenses of several members of the board of engineers and officers of The Cataract Construction Company attending the sessions of the commission and in connection therewith.

The payments made to foreign consulting engineers during the years 1891–1893, including the expenses of the commission, amounted to $75,872, not including additional payments made after 1893, from time to time, for expert advice by foreign constructing as well as consulting engineers.[1]

REPORT ON THE PROJECTS

As soon as practicable after the commission had adjourned and its affairs had been brought to a conclusion, Prof. W. C. Unwin, secretary of the commission, presented his report on the projects submitted to the International Niagara Commission accompanied by the following statement:

London, April 13, 1891

The Cataract Construction Company having asked for a report on the plans submitted to the commission, the secretary has prepared the following statement. The commission having separated, it is not possible to have an official report carrying the authority of the commission.

The report[2] is in three parts. The first sets forth the power problem at Niagara which was the basis for the invitation for projects and a summary of the projects received: the second is a detailed abstract of the projects received and the final part lists the award of prizes and premiums and states the general conclusions.

The report not only presents a vital episode in the history of The Niagara Falls Power Company but it is a historic document presenting in an authoritative way the state of the art of power transmission at the beginning of 1891. The fact that none of the proposals for distribution of power was regarded as worthy of a prize or adequate to the requirements at Niagara and the fact that a little over two years later a system was adopted which is in universal practise makes clear the great step that was taken at Niagara. It was a step which called for courage—the courage of leadership.

THE SERVICE RENDERED BY THE COMMISSION

On the evening of February 4, 1891, the day on which the commission completed its labors, the president of The Cataract Construction Company and the president of the commission exchanged greetings by cable:

Sir William Thomson, London

The directors of the Cataract company thank you and your associates for your careful consideration and decisions. We believe the International Niagara Commission

[1] For details of total foreign expenditures of $430,000, see Appendix O, Volume II.

[2] Appendix E, Volume I.

will become of historical importance in the annals of industrial progress, and mark an epoch of international fraternity in the solution of great scientific problems. We most cordially invite you all to the opening ceremonies

Adams.

Cataract Construction Company, New York

La commission en terminant ses travaux adresse à Monsieur Adams ses vifs remerciments pour les relations si courtoises qu'elle a trouvées auprès de lui. Elle exprime tous ses voeux pour le succès de l'entreprise du Niagara.

Thomson.

At the last session of the commission a resolution was recorded expressing the appreciative thanks of its members to Professor Unwin for his untiring and valuable services as secretary.

After the last official meeting of the International Niagara Commission and prior to the members' separation after the award of the prizes and bonuses, the president of the commission, Sir William Thomson, entertained his associate commissioners at dinner, at the Whitehall Club, London, to which he invited several of the prominent scientists, engineers and financiers of England and several from the continent.

Niagara as a topic, the proceedings of the commission, and the probable results of its action, were found of extraordinary interest.

Messrs. Herschel and Porter made a visit in February to Switzerland and Paris to meet some of the competitors and to learn their reaction from the sessions and conclusions of the commission. It may be expressed as follows:

Electricity or compressed air for transmission of power: alternating current attractive.

Central station development and distribution approved.

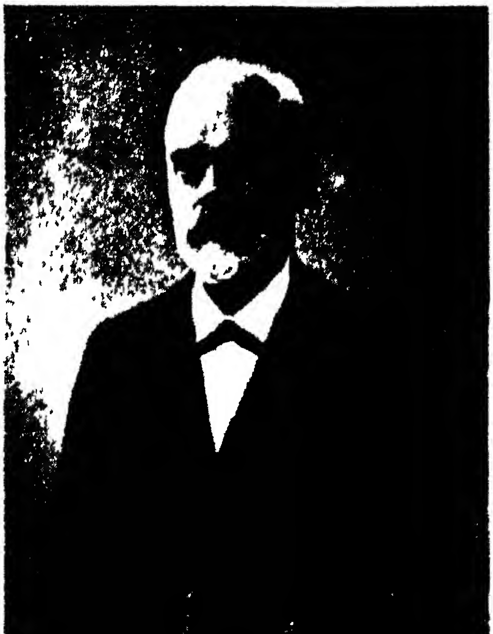
Larger and still larger prime movers and generators or compressors as new projects are prepared.

Foreign engineers expected to assist in the organization and installation at Niagara Falls.

General satisfaction with the organization of the commission and its fairness and liberality in dealing with the contestants.

After calling upon the engineers, who had shown an interest in the Niagara enterprise, at Geneva, Winterthur, Zurich, Oerlikon, Paris and London, they sailed for New York, February 11, 1891, thus ending the eastward pilgrimage for scientific information applicable to the utilization of the waters of Niagara River.

Messrs. Unwin and Turrettini, of the International Niagara Commission visited the Frankfort Exhibition in the interest, partially at least, of the Niagara project, and both were subsequently retained by the cataract company as foreign consulting engineers. They made several visits to Niagara and assisted personally in the company's consideration of the electrical system to be adopted. Their counsels were greatly valued in the determination of the



Imp. Ch. Wittmann

E. Mascart
Physicist
1837-1908

efficiency of the turbine and generator designs submitted to the company by the foreign and American manufacturers.

In his report of March 6, 1891, Dr. Coleman Sellers, chief engineer, wrote The Cataract Construction Company:

What has been accomplished by means of the International Commission may be expressed in few words. It has shown us what we can reasonably hope to do; it has shown us in a degree how to do what is wanted and where we can expect to get what we require

to do the work. It has brought the scheme before the world with a prestige that cannot be measured by dollars, it has enlisted the interest of the whole scientific world, it has made this company command the confidence of the world and won for its management respect, as wise, far-seeing, cautious business men and not followers of any one or more visionary schemer or inventor.

Prof. E. Mascart, the commissioner from France, wrote from Paris, June 29, 1891:

Cette grande entreprise marquera une date importante dans l'histoire des applications de l'électricité et je tiens pour un grand honneur d'y avoir pris une part, si petite qu'elle soit.

E. MASCART
Directeur
Bureau Central Météorologique

ANDRÉ HILLAIRET[1]
1857–1926
Ingénieur des Arts et Manufactures
Ancien Président des Ingénieurs Civils de France
Ancien Président de la Société Française des Électriciens
Chevalier de la Légion d'Honneur

DESIGNER OF THE ONLY PROJECT OF 10,000 HORSE-POWER UNITS
SUBMITTED TO THE INTERNATIONAL NIAGARA COMMISSION

[1] See Appendix E, pages 421, 443 and 444.

RELATED AND ASSOCIATED COMPANIES
ORGANIZATION—FINANCE

HYDRAULIC RIGHTS AND FEDERAL RESTRICTIONS

CHAPTER XI

(In Four Parts)

Contributed by

Frederick L. Lovelace, a Director and Secretary of
The Niagara Falls Power Company

The Rights

to take water for power purposes by

THE NIAGARA FALLS POWER COMPANY (MCMXVIII)

are based upon grants to its constituent companies

and its subsequent federal license

1. The Niagara Falls Power Company, chartered in 1886 under name of Niagara River Hydraulic Tunnel, Power and Sewer Company.

2. Hydraulic Power Company of Niagara Falls and its predecessor, The Niagara Falls Hydraulic Power and Manufacturing Company, chartered in 1878.

3. Canadian Niagara Power Company, Limited.

These rights, in various legal forms, are derived from

The Common Law,

The State of New York,

The Congress of United States,

The War Department of United States,

The Federal Water Power Commission,

Province of Ontario, Canada,

Dominion of Canada,

and are described herein by

Frederick L. Lovelace, Secretary,

The Niagara Falls Power Company.

HYDRAULIC RIGHTS AND FEDERAL RESTRICTIONS

CHAPTER XI

Part I

NEW YORK STATE LAWS, 1857–1918

THE RIGHT TO USE WATERS OF NIAGARA RIVER IN POWER PRODUCTION

THE Niagara Falls Power Company produces the power furnished by it by utilizing the energy of the flow or fall of the Niagara River from the level above the upper rapids to that immediately below the Great Falls.

Water is diverted from the river channel about a mile above the American Falls. After being passed through hydraulic turbines all the diverted water is returned to its natural course in the first pool below that falls.

The company owns the uplands along the shore of the river and lands under water at the places of water diversion and for a distance of about 2 miles up the American shore. It also owns the shore lands where the water is returned below the falls and for a considerable distance above the points of discharge. The only American shores owned by others between the places of diversion where now made and return are lands within the New York State Reservation at Niagara, where the fee of the lands is in the State of New York, which by acts of its legislature has consented to such diversion. In addition to the state reservation lands about 165 feet, known as the "Ten-Rod Strip" (now a part of Porter Park), intervene between the intake and discharge of the company's "Niagara" plant. It was formerly owned by The Niagara Falls Power Company (constituent) and by it donated to the city of Niagara Falls to be used only for purposes of a park and a public dock, the company having reserved to itself and its successors the property and rights therein necessary for the production of power.

SOURCES OF THE COMPANY'S RIGHTS

The right of the company so to divert and use the water of the river is based

1. upon ownership of (a) the uplands and bank of the stream where water is diverted, (b) abutting lands under water, and (c) shore lands where the water is returned;

2. upon (a) a grant by the State of New York to one of the constituent corporations, (b) a specific declaration and confirmation by the state of the rights exercised by another of the constituent corporations, and (c) the consent of the state that all the rights

of the constituent corporations may be enjoyed by the present (consolidated) company, and treated in this Part I;

3. upon a 50-year license of the Federal Power Commission, acting by authority of the Congress, treated in Part III.

RIPARIAN OWNERSHIP

The first ("1" above) is a right inherent in, pertaining to, and a part of, the company's real property. It is wholly independent of rights not appurtenant to the lands obtained through governmental grants, licenses or otherwise, but is not repugnant thereto. Both this property right and such grants and licenses and their confirmation are limited by certain paramount rights of the public in the stream, the most important of which is navigation. Excepting in respect of such paramount public rights under the Common Law as it prevails in the State of New York the riparian owner may divert upon his lands water for manufacturing purposes without other restriction than the physical limitation of the particular location and rights of other riparian owners.

In the case under consideration the State of New York, which is the private proprietor of the lands in the state reservation at Niagara, is the only other riparian owner on the American side of the river whose rights could be affected. By statutory enactment, the state has expressly consented to such water diversion and has thereby waived any conflicting rights of its private riparian ownership.

Rights of the owners of shore lands were defined in an opinion of the New York Court of Appeals, as follows:

> The rule of law is familiar that each owner of land contiguous to a natural watercourse has a right, as owner of such land and as naturally connected with and incident to it, to the natural flow of the stream along his land and its descent, and all the force to be derived therefrom, for any domestic or hydraulic purpose to which he may decide to apply it. He may, by means of a ditch or conduit, withdraw water from the stream and cause it to flow unnaturally through his land for agricultural, industrial or other purpose, provided he causes it, in its substantial volume to return upon his land to the stream. . . . Every owner is bound to use the water reasonably as it flows so as not to injure the equal rights of all the owners. Whether or not a use or detention of the water is reasonable must be determined by the extent and capacity of the stream, the uses to which it is and has been put and the rights that other owners on the stream have. . . . The rights involved in the instant dispute arose from the lateral contact of the lands of Thomson and Dix with the waters of the river, arrested and restrained by the dam. The navigability of the river or the ownership of the soil over which the waters flow neither increase nor diminish rights of such a nature. They are at no point of the discussion here connected with the right of navigation or other public right or with the occupation or use of the bed of the stream. The right to the use of the water of a

flowing stream, navigable or unnavigable, arises by mere operation of law as incident to the ownership of the bank and is a part of the estate of its owner. . . . It is a valuable property right which can be severed from the riparian land by grant, condemnation, relinquishment or prescription. Thomson and Dix as owners of the single tract might release it or grant it to another or restrict or reserve it as owners of the single tract to specified uses or places.

The United Paper Board Company vs. Iroquois Pulp and Paper Company (decided March, 1919) 226 N. Y. 38

GRANTS AND LIMITATIONS

The use of the water of the Niagara River in power production and the construction of extensive works for such use by the corporations which were consolidated into The Niagara Falls Power Company in 1918 (including predecessors of one of them), proceeded from the time of the first use through the hydraulic canal (construction of which was begun in 1852) until the year 1892, and on the part of one company until 1896. in reliance mainly upon their respective proprietary rights as riparian owners.

The Niagara Falls Hydraulic Power and Manufacturing Company, the immediate predecessor in title of Hydraulic Power Company of Niagara Falls (one of the constituent corporations of The Niagara Falls Power Company, MCMXVIII) was incorporated by Jacob F. Schoellkopf and associates in 1878 under the laws of New York. It succeeded by purchase to the title of the hydraulic canal and the other property and rights of the "Day" hydraulic power development. The lands owned by it consisted, mainly, of (1) uplands and lands under water at Port Day about a mile above the American Falls adjoining what is now the upper limit of the New York State Reservation at Niagara, (2) a large tract fronting on the lower river, and (3) a connecting strip 100 feet wide granted for hydraulic canal purposes by the owners of the intervening shore lands. Through this 100-foot strip the "Day" or "hydraulic" canal diverted water from the upper river and led it to a receiving basin near the high bank of the lower river on the large tract mentioned. The construction of the canal had been started in 1852. From time to time after the year 1857, when the canal was sufficiently completed for use, mills had been built on its terminal basin, taking water therefrom for power production and discharging the spent water through the high bank into the lower river.

The State of New York by an act of its legislature, Chapter 968 of the laws of 1896, "recognized, declared and confirmed" the right of The Niagara Falls Hydraulic Power and Manufacturing Company to take and use the water of the Niagara River and to develop power therefrom and sell the same. The act expressly limited and restricted the confirmation of the rights of the

company to the use by the company of "such quantity of water as may be drawn by means of the hydraulic canal of said company when enlarged throughout its entire length to a width of 100 feet and to a depth and slope sufficient to carry at all times a maximum uniform depth of 14 feet of water," and also contained a proviso that the exercise by the company of the "rights hereby declared and confirmed shall not impair the practical navigation of the Niagara River."

In a decision of the New York Supreme Court, affirmed by the Appellate Division of that court and by the Court of Appeals, it was held that The Niagara Falls Hydraulic Power and Manufacturing Company had property rights, as distinguished from a "franchise," entitling it to divert water from the river for power production.

In its opinion the Court stated:

> The relator, as a riparian owner, and as owner of the lands under the waters of the Niagara River adjacent to its uplands from which the water is immediately taken, has the right to the use of the waters of the river for manufacturing purposes, and to divert the same for that purpose, returning them to the river as it does after passing over its own lands; . . . subject only to the paramount right of the state to utilize these waters for a public use, without compensation to such riparian owners; all riparian rights remaining unimpaired until the exercise of such paramount right by the state This being so, it appears that the relator, as riparian owner, had the right to take waters from the Niagara River for manufacturing purposes, not interfering thereby with the navigability of the stream, such right being in no sense in the nature of a franchise but a corporeal hereditament, not depending either upon grant or prescription. . . . And this view of the relator's rights is confirmed by the act of 1896 (Chapter 968) . . . which in terms confirms and defines the riparian rights of the relator

The People ex rel. Niagara Falls Hy. Power & Mfg. Co. vs. Smith
70 App. Div. 543, affirmed 175 N. Y. 469

The Niagara Falls Power Company (the constituent corporation of that name) was chartered March 31, 1886, under the name of "The Niagara River Hydraulic Tunnel, Power & Sewer Company" by an act of the legislature of the State of New York, Chapter 83 of the laws of 1886. Its charter was amended or enlarged by subsequent acts, as follows:

(1) Chapter 489 of the laws of 1886;
(2) Chapter 109 of the laws of 1889,
(3) Chapter 253 of the laws of 1891;
(4) Chapter 513 of the laws of 1892;
(5) Chapter 477 of the laws of 1893.

Its name was changed to The Niagara Falls Power Company by an order of the New York Supreme Court entered November 11, 1889.

Construction of the company's works was begun in 1890. Actual electric power production began in 1895.

The charter as originally enacted had declared that the corporation was constituted a body corporate and politic for the purpose of "constructing, maintaining, and operating in connection with the Niagara River an hydraulic tunnel . . . and for furnishing hydraulic power for manufacturing purposes." It provides, among other things, that the company should have the power to construct, operate and maintain for its corporate purposes a tunnel, conduits, or sewers as specified in the act, or under the waters of the Niagara River, provided such structures are so laid as not to interfere with navigation of the river.

While clear that the legislature understood and intended that the company was being chartered for the express purpose of producing power by use of water diverted from the Niagara River, neither the original act nor any of the earlier amendatory acts contained a grant for such purpose in explicit terms. It was assumed that the common law right of a riparian owner was adequate for that purpose.

In 1892, the State of New York by an act of its legislature (Chapter 513 of 1892) granted The Niagara Falls Power Company, its successors and assigns, the "right to take and use the waters of the Niagara River . . . at any points on or opposite to any riparian land now owned by said corporation . . . to the extent required for the proper operation of the authorized works of said corporation during the continuance of such works."

The grant provided that nothing contained therein or in any of the former acts concerning the corporation should be construed "to confer an exclusive right nor any right to infringe upon the state reservation or to obstruct the navigation of the Niagara River, or to take therefrom more water than shall be sufficient to produce 200,000 effective horse-power."

Besides having sovereign jurisdiction, the state had rights as a private riparian owner between the places of diversion and return. Its consent as such riparian owner to water diversion as made by the company was thus obtained.

While the bill (later enacted as Chapter 513 of 1892) was pending in the legislature, the Hon. Andrew H. Green, then president of the Board of Commissioners of the state reservation at Niagara, called the attention of the governor and of the attorney-general of the state to the terms and conditions of the grant, which he intimated would likely constitute a contract between the state and the company. Such a probability was expressly recognized by the attorney-general in his formal published opinion (Report of Attorney-General for the year 1892; Opinions, page 106). When it became a law The

Niagara Falls Power Company filed with the Secretary of State of the State of New York its acceptance of the grant and of the terms and conditions upon which it was made and the original company and its successor company have complied fully with the terms of the act.

The present The Niagara Falls Power Company was formed in October, 1918, by consolidation, pursuant to Chapter 596 of the laws of 1918, of Cliff Electrical Distributing Company (incorporated 1909), The Niagara Falls Power Company (incorporated 1886), and Hydraulic Power Company of Niagara Falls (incorporated 1910).

Chapter 597 of the laws of 1918 authorizes the consolidated company to exercise all powers theretofore or thereafter conferred upon either or all of the constituent corporations, provided (1) that nothing in the statute contained shall authorize the consolidated company to divert from the Niagara River any water in excess of the amount theretofore authorized by the State of New York in respect of the constituent companies, and (2) that if the consolidated company shall divert more than 15,100 cubic feet per second there shall be reserved to the state the right to charge an equitable rental for the excess.

Part II

THE CONGRESS OF THE UNITED STATES

Legislation and Reports Regarding the Preservation of Niagara Falls Permits under the Burton Law 1906–1913

HISTORY

At the time of the adoption of the Constitution of the United States, and for some years thereafter, the State of New York was the sole proprietor of all the shore lands and lands under the waters of the Niagara River on the United States side of the boundary between it and Canada and of the usufruct of the flow of the water on that side of the boundary.

Subsequently, from time to time, all the shore lands and a considerable part of abutting lands under shallow waters were granted by the state by patent to individuals or corporations. In 1884 the state re-acquired by purchase or expropriation that part thereof now embraced in the New York State Reservation at Niagara, which includes all the shore lands on the American side of the river between the lands where The Niagara Falls Power Company now takes water from the river to develop power and the lands from which it returns such waters again to their natural channel. By acts of its legislature in 1892 and 1896 respectively, as above mentioned, the state granted to one of the constituent corporations of The Niagara Falls Power Company and confirmed in another thereof rights to the use of the waters of the Niagara River which are now exercised to the extent permitted by the Federal Government.

The State of New York has sovereign jurisdiction over the river and the flow of its waters for every purpose except those heretofore expressly delegated by it to the Congress, namely, purposes pertaining to commerce (which includes navigation) and national defense.

The Federal Government never had and has not now any proprietary interest in the shores or in the bed of the Niagara River, and has no right of usufruct of the flow of its waters under any existing or foreseeable situation.

WATER DIVERTED FROM THE FALLS BY POWER COMPANIES CHARTERED BY NEW YORK STATE

Diversion of water from the Niagara River for power purposes by the predecessors of the present The Niagara Falls Power Company continued until 1906 without attempt on the part of the Congress or of any department of the

Federal Government to limit or control it. Until that time no claim had been made that such diversions came within the scope of the limited jurisdiction of the Congress.

INTERNATIONAL WATERWAYS COMMISSION

On March 27, 1906, President Roosevelt submitted to the Congress a report by the American members of the International Waterways Commission regarding "the preservation of Niagara Falls." With that report were included "memoranda showing what has been attempted by the Department of State in the effort to secure the preservation of the falls by treaty."

The report contained the following recommendations:

(a) The Secretary of War to be authorized to grant permits for the diversion of 28,500 cubic feet per second, and no more, from the waters naturally tributary to Niagara Falls, distributed as follows:

	Cubic feet
The Niagara Falls Hydraulic Power and Manufacturing Company	9,500
The Niagara Falls Power Company	8,600
Erie Canal or its tenants (in addition to lock service)	400
Chicago Drainage Canal	10,000

(b) All other diversion of water which is naturally tributary to Niagara Falls to be prohibited, except such as may be required for domestic use or for the service of locks in navigation canals

(c) Suitable penalties for violation of the law to be prescribed.

(d) The foregoing prohibition to remain in force two years, and then to become the permanent law of the land, if, in the meantime, the Canadian Government shall have enacted legislation prohibiting the diversion of water which is naturally tributary to Niagara Falls, in excess of 36,000 cubic feet per second, not including the amounts required for domestic use for the service of locks in navigation canals. It is assumed, however, that an understanding upon this subject would be reached by treaty.

The object of such legislation would be to put a stop to the further depletion of the falls, and at the same time inflict the least possible injury upon the important interests now dependent upon this water-power. The amount to be diverted on the Canadian side has been fixed with a view to allowing to the companies on that side the amounts for which they now have works under construction, which are:

	Cubic feet
Canadian Niagara Power Company	9,500
Ontario Power Company	12,000
Electrical Development Company	11,200
Niagara Falls Park Railway Company	1,500
Welland Canal or its tenants (in addition to lock service)	1,800

In submitting the report President Roosevelt said:

I earnestly recommend that Congress enact into law the suggestions of the American members of the International Waterways Commission for the preservation of Niagara Falls, without waiting for the negotiation of a treaty. . . . In any event I hope that this nation will make it evident that it is doing all in its power to preserve the great scenic wonder, the existence of which, unharmed, should be a matter of pride to every dweller on this continent.

THE BURTON ACT

Theodore E. Burton, then a member of the House of Representatives and chairman of its Committee on Rivers and Harbors, introduced a bill seeking to enact into law the recommendations of the commission with certain modifications. The proceedings and the debate showed the purpose of the bill to be solely the preservation of Niagara Falls—a local matter of which the State of New York and not the Federal Government would seem to have sole jurisdiction.

Notwithstanding objections of the State of New York and of those whose interests were likely to be adversely affected, the Burton Bill became a law by the approval of President Roosevelt on June 29, 1906.

The act authorized the Secretary of War to grant:

(a) Permits for the diversion of water from the Niagara River or its tributaries for the creation of power, but only to companies then actually producing power from the waters of that river or its tributaries in the State of New York or from the Erie Canal, and only to the amount then actually in use or contracted to be used in factories the buildings for which were in process of construction, and not exceeding to any one permittee a maximum amount of 8600 cubic feet per second, and not exceeding to all an aggregate amount of 15,600 cubic feet per second.

(b) Permits for the transmission of power from the Dominion of Canada into the United States in an amount in the aggregate not in excess of 160,000 horse-power;

(c) Revocable permits for diversion of additional amounts of water "to such amount, if any as, in connection with the amount diverted on the Canadian side, shall not injure or interfere with the navigable capacity of said river, or its integrity and proper volume as a boundary stream, or the scenic grandeur of Niagara Falls".

(d) Revocable permits for the transmission of additional electrical power from Canada "but in no event shall the amount included in such permits, together with the said 160,000 horse-power and the amount generated and used in Canada, exceed 350,000 horse-power."

Diversion of water from the Niagara River or its tributaries other than as permitted by the Secretary of War pursuant to the act was prohibited, with the proviso that such prohibition should not be interpreted as forbidding "the diversion of water of the Great Lakes or of Niagara River for sanitary or

domestic purposes or for navigation; the amount of which may be fixed from time to time by the Congress of the United States or by the Secretary of War of the United States under its direction."

The act also contained the following provisions:

Sec. 4. That the President of the United States is respectfully requested to open negotiations with the government of Great Britain for the purpose of effectually providing by suitable treaty with said government, for such regulation and control of the waters of Niagara River and its tributaries as will preserve the scenic grandeur of Niagara Falls and of the rapids in said river.

Sec 5. That the provisions of this act shall remain in force for three years from and after date of its passage, at the expiration of which time all permits granted hereunder by the Secretary of War shall terminate unless sooner revoked, and the Secretary of War is hereby authorized to revoke any or all permits granted by him by authority of this act, and nothing herein contained shall be held to confirm, establish, or confer any rights heretofore claimed or exercised in the diversion of water or the transmission of power.

Substantial penalties were provided for violations of the provisions of the act.

From time to time as the respective terms of the act and its extensions drew near or passed expiration, the operation of the Burton Law, substantially unchanged, was extended until final expiration on March 4, 1913.

The Niagara Falls Power Company (constituent) filed with the Secretary of War July 5, 1906, under protest as hereinafter set forth, its applications dated July 3, 1906, for permits under the Burton Law, respectively, (1) to divert 8600 cubic feet of water per second from the Niagara River on the American side for power production, and (2) to transmit electricity from the plant in Canada of its subsidiary corporation (Canadian Niagara Power Company, Limited) into the United States to the amount of 121,000 horsepower, the Canadian Niagara Power Company, Limited, joining in the latter application.

An application was filed at the same time by The Niagara Falls Hydraulic Power and Manufacturing Company (predecessor of another of the constituent corporations of the present The Niagara Falls Power Company) for a permit to divert 9500 cubic feet per second on the American side for power production in its plant.

Applications were also filed by others (1) for permits to transmit into the United States electric power generated by companies on the Canadian side of the river, and (2) for diversion within the State of New York by companies claiming rights therefor, but without constructed facilities for utilizing the water.

The application of The Niagara Falls Power Company (constituent) for a diversion permit included the following statements:

The Niagara Falls Power Company . . . recognizing that under the menace of the stringent provisions of and the severe penalties imposed by the act of the first session of the Fifty-ninth Congress entitled "An Act for the Control and Regulation of the Waters of Niagara River, for the Preservation of Niagara Falls, and for other Purposes," it will be impossible for the applicant to conduct its business except under the authority of the permit of the Secretary of War referred to and provided for in Section 2 of the said act, in its own behalf and in behalf of its power tenants hereinafter described, and under the provisions of the said act hereby respectfully applies to the Secretary of War for

A permit for the diversion of water in the United States from the Niagara River, for the creation of power to the amount of eight thousand six hundred (8600) *cubic feet per second.*

This is the amount of water of said Niagara River now actually in use by the applicant, as reported by the International Waterways Commission, Senate Document 242 (Sixty-second Congress, Second Session), Art. 9, p. 5, Art. 30, p. 11.

The applicant, however, respectfully PROTESTS against the provisions of the said act in so far as the same prohibit or are inconsistent with the present and continued exercise by the applicant of its just and lawful right, during the continuance of its works, to divert the waters of the said Niagara River and to use the same for the creation of power, to an extent sufficient to produce 200,000 effective horse-power, and WITHOUT WAIVING, respectfully reserves the applicant's said right, and all right now vested in it, or to which it is now entitled (1) under the Common Law, or (2) under the Statutes of the State of New York.

HEARINGS AND REPORTS ON APPLICATIONS FOR PERMITS

Hearings on the applications for water diversion on the New York side of the river were conducted by Secretary of War William H. Taft, in person, at his office in Washington, on July 5th, and at Niagara Falls, New York, on July 12, 1906. On July 14, 1906, Secretary Taft issued an interlocutory order granting certain temporary permits governing diversion on the New York State side of the river and transmission into the United States from Canada, until final determination of the matter by him, and referring all applications for permits to Captain (later Colonel) Charles W. Kutz, then of the Corps of Engineers, United States Army, and the American members of the International Waterways Commission to report on the facts.

Captain Kutz, who made extensive investigations on the ground, filed with the Secretary of War his report on the "Existing Water-power Situation at Niagara Falls, so far as Concerns the Canadian Power Companies and Their Associated Transmission Companies," dated August 15, 1906, and also a report on "Existing Water-power Situation at Niagara Falls, so far as Concerns the Diversion of Water on the American Side," dated October 5, 1906.

In the report on transmission from Canada into the United States the recommendations were:

That permits for the transmission of power to the United States be issued as follows:

	Horse-power
Niagara, Lockport & Ontario Power Company, from the Ontario Power Company	60,000
Electrical Transmission Company, from the Electrical Development Company	37,500
The Niagara Falls Power Company, from the Canadian Niagara Power Company	60,000

The American members of the International Waterways Commission filed a report on the same subject dated September 29, 1906, in which they concurred in the recommendations made by Captain Kutz.

In his report on water diversion on the New York side of the river, Captain Kutz stated:

If it be determined that the amount of water occasionally used for sluicing debris and ice must be included in any permits that are granted, the interested parties are, in my opinion, entitled under the law to permits for diversion as follows

	Cubic feet per second
The Niagara Falls Power Company	8,600
The Niagara Falls Hydraulic Power & Manufacturing Company	6,403
State of New York (at Lockport, New York, through the Erie Canal)	358

The American members of the International Waterways Commission reported on water diversion under date of November 15, 1906. Their report contained the following recommendation:

We accordingly recommend that permits for the diversion of water from the Niagara River be granted to The Niagara Falls Power Company for 8600 cubic feet per second and The Niagara Falls Hydraulic Power and Manufacturing Company for 5850 cubic feet per second, it being understood that these are average amounts, and that the larger amounts occasionally required for sluicing may be accumulated by using generally smaller amounts.

A further hearing on the several applications for permits to transmit electricity from Canada into the United States was held by Secretary of War Taft at his office in Washington lasting two days, November 26 and 27, 1906. At that hearing Francis Lynde Stetson appeared for The Niagara Falls Power Company; John L. Romer for The Niagara Falls Hydraulic Power and Manufacturing Company; Paul D. Cravath for Niagara, Lockport &

Ontario Power Company; Morris Cohn, Jr., for International Railway Company; John G. Johnson (of Philadelphia) for Electrical Development Company; A. K. Potter for the commissioners of the state reservation at Niagara; Frank W. Stevens for the New York Chamber of Commerce; J. Horace McFarland of the American Civic Association, Dr. John M. Clarke, New York State Geologist and several others appeared as stated in the public interest.

PERMITS UNDER THE BURTON LAW

On August 16, 1907, the Secretary of War issued to The Niagara Falls Power Company (1886) (1) a permit to divert 8600 cubic feet of water per second from the Niagara River above the falls for use for power purposes, (2) a permit to receive from Canadian Niagara Power Company, Limited, at the international boundary line and to transmit from the Dominion of Canada into the United States 52,500 electrical horse-power.

At the same time a permit for diversion of 6500 cubic feet of water per second from above the falls was issued to The Niagara Falls Hydraulic Power and Manufacturing Company. The amount of water so permitted to that company anticipated provision for certain plant enlargements in process when the Burton Law was enacted.

A diversion permit for 500 cubic feet per second was issued also to the Lockport Hydraulic Company, the diversion to be made through the Erie Canal to Lockport.

Further permits for transmission of electricity into the United States from Canada also were issued (1) to the Niagara, Lockport and Ontario Power Company in the amount of 60,000 horse-power, (2) to The Electrical Development Company of Ontario, Limited, and its distributing agents in the United States in the amount of 46,000 horse-power, and (3) to the International Railway Company in the amount of 1500 horse-power.

UNITED STATES LAKE SURVEY REPORTS

For the guidance of the Congress and the treaty commissioners who were meantime appointed and were engaged with commissioners on behalf of Great Britain in formulating a treaty for the control of the waters of boundary streams between Canada and the United States, at the instance of the Secretary of War exhaustive investigations were undertaken of the effect on the falls, as well as on the river and the levels of Lake Erie, of the diversion of water for power purposes both in Canada and in the United States. Surveys, measurements, and careful studies were made by the United States Lake Survey whose findings and conclusions were embodied in reports to the Chief of Engineers, United States Army, by Major (afterwards General) Keller,

Corps of Engineers, United States Army, then in charge of the survey of the northern and northwestern lakes, dated November 30, 1908, and September 21, 1909, respectively, and transmitted by President Taft to the Congress on August 21, 1911. They were printed in Senate Document No. 105, Sixty-second Congress, First Session, under title "Preservation of Niagara Falls." A further report was made by Colonel Riché, then the successor to Major Keller in charge of the United States Lake Survey, dated September 11, 1911, which was transmitted by the President to the Congress on December 7, 1911, and printed under the same title in House Document No. 246, Sixty-second Congress, Second Session.

The effect on Lake Erie and Niagara River levels of all diversions for power purposes then being made on the Canadian as well as the American side, was stated by Major Keller as follows (the amounts being in fractions of one foot):

Lake Erie (Buffalo L. H. gauge)	.07	*of a foot*
Niagara River at—		
Austin Street	.10	"
Tonawanda.	.16	"
Schlosser's Dock	.23	"
Chippawa	.48	"
Grass Island	.77	"

The change at Grass Island exceeds that at Chippawa because of localized effect due to the close proximity of the intakes of the two American power companies. With diversions at points in the pool remote from both gauges, the latter should change by an equal amount. The shut-down of July-August, 1908, also shows that a change of diversion in the Chippawa-Grass Island pool is accompanied by a corresponding change in outflow of Lake Erie, amounting to 10 per cent of the change in diversion.

Although the traffic below Tonawanda is insignificant in draft and in amount, the upper Niagara River is navigable from its head practically to Chippawa and Schlosser's Dock. . . . In inches, the diversion of 19,350 cubic feet per second in the Chippawa-Grass Island pool reduces the depth at the head of the river $7/8$ inch, at Austin Street $1\,1/4$ inches, at Tonawanda $1\,7/8$ inches, at Schlosser's Dock $2\,3/4$ inches, and at Chippawa $5\,3/4$ inches. The change to and including Tonawanda is insignificant. Below that point the reduction in depth is greater, but there is still much more than enough depth for the commerce involved.

In reply to the inquiry of the Chief of Engineers, I would, therefore, state categorically that the diversion of the maximum amount at present authorized on the American side, a total of 15,100 cubic feet per second, and the additional diversion on the Canadian side of all the water needed to generate the 60,000 horse-power, at present permitted to be imported into the United States by the Ontario Power Company, will not injure nor interfere with the navigable capacity of the Niagara River. . . . It is therefore plain that present authorized diversions in the United States and those now made in Canada,

have had no effect upon the Niagara River, so far as concerns "its integrity or proper volume as a boundary stream."

Senate Document 105 (Sixty-second Congress, First Session), pages 12-13

POWER PLANTS SHUT DOWN IN 1908

The investigations of the United States Lake Survey engineers were assisted by shut-downs of the American power-plants for several hours at a time in June and July, 1908. The shut-downs of The Niagara Falls Power Company (constituent) plant were made primarily for the purpose of repairs in Power-house Number Two extension of its tail-race tunnel. The plant of The Niagara Falls Hydraulic Power and Manufacturing Company was shut down simultaneously for the express purpose of assisting the United States War Department engineers in their measurements of water levels in the river.

The results of such measurements were reported by Major Keller as follows:

> Accordingly, the positive evidence of the shut-down of July-August, 1908, shows very slight change in the height, and therefore in the volume of the American Falls, due to the restoration to the upper rapids of some 5600 cubic feet per second. The actual change, ascertained from the comparison of the means of two 10-day periods, was a rise of 0.012 foot at the Prospect Point gauge, situated at the American or northeast end of the American Fall. At gauge, wing dam, nearly opposite the head of Goat Island, the rise was 0.037 foot. The law of gauge relations, on the other hand, would have made the rise at Prospect Point 126/560 of the rise at Chippawa, or about 0.026 foot, and at wing dam 41/56 of the rise at Chippawa, or about 0.068 foot. The effect actually observed is therefore less than half that which is derived from a consideration of the law of gauge relations. A diversion of 15,100 cubic feet per second on the American side would therefore actually lower the American Fall at Prospect Point 0.032 foot, or about 2 per cent of its average depth. While the change at the middle point of the crest might perhaps not be the same as that at Prospect Point, it is doubtful whether the difference would be appreciable. The present authorized diversions of the two American companies and that at present possible for the Ontario Power Company together will lower the depth of water on the American Fall 0.052 foot, equivalent to about $\frac{5}{8}$ inch, and on the American rapids the lowering will be about 0.30 foot, or $3\frac{5}{8}$ inches, and these changes can not be considered as important.
>
> The effect of a diversion of 15,100 cubic feet at Terrapin Point, at the east end of the Horseshoe, is shown by the established law of gauge relations to be a lowering of 0.16 foot, and for a diversion of 19,350 cubic feet, which covers all present and immediately prospective diversions in the Chippawa-Grass Island pool, the reduction in depth will be 0.21 foot, or 2.5 inches. As the depths at Terrapin Point are slight, such a lowering is of considerable importance. It is, however, at the west end of the Horseshoe Fall that the most serious effects have been produced. The law of gauge relations shows that a diversion of 19,350 cubic feet in the Chippawa-Grass Island pool will lower the water surface at the Canadian end of the great cataract by 0.52 foot. The present diversions of

the Electrical Development Company, the Canadian Niagara Company, and the International Railway Company, perhaps aggregating 6700 cubic feet, add at least 0.19 foot to this, so that the total lowering at the Canadian end of the Horseshoe Fall, due to diversions authorized on the American side and those existing on the Canadian side, is 0.72 foot or more, a serious change at a locality known to be deficient in depth. These figures are for an elevation of Lake Erie such as obtained during the summers of 1907 and 1908, when lake stages were relatively high.

Senate Document 105 (Supra), pages 13–14

The report adds:

It is understood that the intention of Congress, as expressed in the act of June 29, 1906, was to preserve to the various power companies rights which had already accrued through the investment of capital and the construction of fixed plant. At that time, upon information supposed to be derived from the company itself, the permit for diversion issued to The Niagara Falls Power Company was for a maximum of 8600 cubic feet per second. The discharge measurements in the company's canal have proved that at times its diversion exceeds 9350 cubic feet per second. This represents the maximum measured flow, and corresponds to a bus-bar output of about 72,000 horse-power. With a safe reserve in each power-house, the switchboard capacity of the existing generators is about 95,000 horse-power. It is possible then that the diversions needed for a maximum profitable use of the existing plant of The Niagara Falls Power Company may reach a total of over 12,000 cubic feet per second. To fix the exact amount would require further measurement. An increase to the limit of the capacity of the existing tail-race tunnel may be regarded as a simple act of justice, but it should be conditioned upon a radical reconstruction of the company's tail-race tunnel and penstocks, so as to insure the utmost economy in the use of water At present, this company realizes only about two-thirds of its available head In fact, even though no additional diversion were authorized, since the only rational ground for permitting diversions of any amount whatever is the resulting economy in the use of coal and other fuel—natural resources which are by no means inexhaustible—a requirement of the utmost possible economy in the use of water would not be unfair. The changes in tail-races, penstocks, and in fact in the entire plant, should be made a subject of close inquiry and regulation. All this is not intended as a criticism of this company, which was a pioneer in the field, and at a time when limitation of water consumption was unthought of and seemed unnecessary.

Id., page 16

BURTON LAW RESTRICTIONS—ERRONEOUS CALCULATIONS

The American members of the International Waterways Commission, on whose report to the Secretary of War, dated March 19, 1906, the provisions of the Burton Law were mainly based, had computed the then existing amount of water diversion by The Niagara Falls Power Company (constituent) to be 8600 cubic feet per second, of which about 8000 cubic feet per second was in use in its 100,000 horse-power electric generating station, Power-houses Numbers One and Two, and about 600 cubic feet per second in the production

of hydraulic power by one of its tenant companies (International Paper Company). The computation was accepted by the Congress in providing in the Burton Law that no permit should be issued to any one company in excess of 8600 cubic feet per second.

Soon after the enactment of the law actual operation demonstrated that the amount of water required to operate those plants fully was approximately 10,500 cubic feet per second. Serious and unintended injustice resulted to The Niagara Falls Power Company by such limitation to 8600 cubic feet per second. Its output was thereby reduced some 20,000 horse-power below former production.

The matter was brought to the attention of the treaty commissioners, who recognizing also the necessities of the other American power generating company in framing a treaty proposed that the limit of aggregate diversion on the American side of the river be raised from 15,600 cubic feet per second, as limited by the Burton Law, to "a daily diversion at the rate of 20,000 cubic feet per second."

The results to be expected on the levels of the river and Lake Erie of a diversion of such an additional 4400 cubic feet per second were shown by careful computations from Major Keller's report to be approximately as follows:

	Inches
At the crest of the American Falls, less than	1/8
At the Canadian end of the Horseshoe Falls, less than	1 7/16
At Lake Erie, approximately . .	1/2

(See Hearings before Committee on Foreign Affairs, January 18, 1912, page 68)

TREATY WITH GREAT BRITAIN FIXING LIMITS OF DIVERSIONS

A treaty based upon the views of the commissioners was signed at Washington, D. C., January 11, 1909, and was proclaimed May 13, 1910. Article V provides as follows:

> The high contracting parties agree that it is expedient to limit the diversion of waters from the Niagara River so that the level of Lake Erie and the flow of the stream shall not be appreciably affected. It is the desire of both parties to accomplish this object with the least possible injury to investments which have already been made in the construction of power-plants on the United States side of the river under grants of authority from the State of New York, and on the Canadian side of the river under licenses authorized by the Dominion of Canada and the Province of Ontario.
>
> So long as this treaty shall remain in force no diversion of the waters of the Niagara River above the falls from the natural course and stream thereof shall be permitted except for the purposes and to the extent hereinafter provided.

The United States may authorize and permit the diversion within the State of New York of the waters of said river above the falls of Niagara, for power purposes, not exceeding in the aggregate a daily diversion at the rate of 20,000 cubic feet of water per second.

The United Kingdom, by the Dominion of Canada, or the Province of Ontario, may authorize and permit the diversion within the Province of Ontario of the waters of said river above the falls of Niagara for power purposes, not exceeding in the aggregate a daily diversion at the rate of 36,000 cubic feet of water per second.

The prohibitions of this article shall not apply to the diversion of water for sanitary or domestic purposes, or for the service of canals for the purposes of navigation.

Notwithstanding enlargement by the terms of the treaty of the limits of water diversion above the falls for power purposes permissible on the New York side of the river, the Congress by the successive joint resolutions extending the operation of the Burton Law until March 4, 1913, made no change in its limitation of the maximum rates of such diversion as originally fixed by the Burton Law.

Part III

UNITED STATES WAR DEPARTMENT

1913–1918

FEDERAL WATER-POWER COMMISSION

License

1921–1925

REQUISITIONS AND CONTROL

The stress of the requirements of the World War and the important part which Niagara power was to take in assisting its prosecution and winning, resulted in recommendations by the War Department (1) for immediate adoption by the Congress of a joint resolution giving the Secretary of War power to grant permits for additional Niagara diversion within treaty limits, in amounts required to operate the existing installations, and (2) for the enactment of a law permanently regulating Niagara diversion so that the companies there would be justified in making the required large investments in installing additional generating machinery and reconstructing their plants to the extent required to utilize the entire head available between the Grass Island pool and that immediately below the falls.

RIVER AND HARBOR ACT OF 1899

Under date of July 19, 1913, General Bixby, then Chief of Engineers, United States Army, on behalf of the War Department, addressed identical letters to each of the New York generating companies, which contained the following notice and statements:

> 1 The attention of all persons diverting water or contemplating the diversion of water from Niagara River for power purposes is invited to the provisions of Sections 10 and 13 of the River and Harbor Act, approved March 3, 1899. Notice is hereby given that all diversions of water from Niagara River above and below the falls are considered by this Department as subject to the provisions of those sections, and consequently as unlawful, except so far as recommended by the Chief of Engineers and approved by the Secretary of War.
>
> 2 For the present, no objection is being made by the War Department to existing diversions so long as the daily average does not exceed that of the permits and diversion limits which existed last year under the Burton Act, but any new diversions will require the specific authority of the Secretary of War. Applications for the necessary authority to change the former diversions or to make new ones, should be addressed to the Secretary of War.

No part of the act referred to by General Bixby, however, seemed applicable to the situation at Niagara Falls. The following provision found in

Section 10 referred to apparently had been construed by the War Department to be applicable:

And it shall not be lawful to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of, any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or inclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same.

MOMENTARY MAXIMUM LIMITATION

It is impracticable to operate central generating stations at a 100 per cent load factor. The effect of the provision of the treaty with Great Britain for a "daily diversion" at a given rate, *i.e.*, averaging the amounts of water used at different times during the day, would have afforded considerable relief from the rigid Burton Law rule, which restricted the use of water to a definite maximum limitation for every moment.

Under date of May 28, 1914, Secretary of War Lindley M. Garrison addressed a letter to The Niagara Falls Power Company containing the following statement and notice:

The maximum relates not to the daily average quantity diverted, but to the quantity diverted at any moment. At no time can that amount be exceeded without destroying the status quo that it is my policy and intention to maintain. You are hereby notified that excess diversions must cease immediately and that your operations must be so conducted as to keep at all times within the maximum limit, namely, 8600 cubic feet per second as prescribed by the permit referred to above, issued to you under the provisions of the Burton Act.

A similar letter was sent to Hydraulic Power Company of Niagara Falls.

Both companies forthwith complied with the terms of the notice, The Niagara Falls Power Company making the following reply to the letter:

The Niagara Falls Power Company

Niagara Falls, N. Y., June 5, 1914.

Honorable Lindley M. Garrison,
Secretary of War,
War Department,
Washington, D. C.

Dear Sir:

We acknowledge receipt at about noon of the 2nd instant of your letter under date of May 28, 1914 (30089/4 W. D. 57243/2555 Engrs).

At the earliest practicable moment thereafter steps were taken to regulate diversion of water by this company within the limits of the permit heretofore issued to it under the Burton Law, and in accordance with the rules and regulations of your department in force immediately prior to the expiration of that law on March 4, 1913.

Upon the expiration of the Burton Law we believed the only rule then restricting such diversion was that of the International Waterways Treaty, limiting the same to "not exceeding in the aggregate a daily diversion at the rate of 20,000 cubic feet of water per second."

Upon March 14, 1913, the then Chief of Engineers orally advised the writer that the diversion then being made by us was not satisfactory and would not be permitted by your department, which he claimed had jurisdiction to restrict such diversion under the provisions of the River and Harbor Act of March 3, 1899, and that until further permits should issue, this company should not exceed a daily diversion at the rate of 8600 cubic feet per second, and all companies must not exceed an aggregate daily diversion at the rate of 15,600 cubic feet per second. Until the receipt of your said letter we received no instructions which we understood to be in revocation of the rule then laid down so clearly.

At all times it has been, and will continue to be, our desire, without waiving our proprietary rights, fully to comply with all provisions of law and with the rules and regulations of your department.

In view of your statement that it is your policy and intention to maintain the status quo of the Burton Act, we appreciate that discussion is useless; nevertheless, for your information and as a matter of record, we desire to bring to your attention at this time briefly two or three pertinent facts:

(1) The limit of diversion imposed upon this company by the Burton Act, namely, 8600 cubic feet per second, was due to an inadvertent error; the intention having been to allow this company to divert the amount of water required for its then existing plant, such amount having already been diverted by it prior to the enactment of that law;

(2) Correction of such unintentional injustice to this company has been recommended repeatedly by engineer officers of the War Department who have been detailed to investigate the subject. In the United States Lake Survey Report on this subject (Senate Document No. 105, Sixty-second Congress, First Session, page 16) in reference to this company, the statement is made: "An increase to the limit of the capacity of the existing tail-race tunnel may be regarded as a simple act of justice," and on page 139 of the same document "The desirability as well as the justice of amending the Burton Act so as to permit The Niagara Falls Power Company to divert water to the full capacity of its tail-race tunnel are plain",

(3) The direction now given by you as to our diversion will have a substantial effect in hampering the industrial operations of our customers who are citizens of the United States. Its effect on scenic conditions, of course, is absolutely nil and its effect upon the navigability and integrity of the Niagara River is infinitesimal.

I have the honor, Sir, to be

Yours very respectfully,
F. L. LOVELACE,
Secretary.

SPECIAL PERMITS FOR BUFFALO

When, because of increases of power use on the Niagara frontier and delays in the installation of a steam-power generating plant in Buffalo, the power

situation became still more critical, the Secretary of War, upon urgent requests from Buffalo, issued special permits, effective during parts of the year 1916 and terminating finally January 1, 1917, to operate the plant of The Niagara Falls Power Company at nearly its full capacity during certain peak-load hours of the day, limiting the use of the additional power thereby generated to Buffalo only, and restricting the production of the plant as before (continued Burton Law restriction) at all other hours of the day.

Upon requests made in the latter part of 1916, for an extension of such special permits, the Secretary of War stated, in substance, that after further consideration he had concluded that he had no authority to extend or to revive the special permits, although he recognized the critical situation of industries at Niagara and in the much wider circle of industries throughout the United States dependent on Niagara power output.

REVOCABLE PERMITS FOR ADDITIONAL DIVERSION

With the approval of the President on January 19, 1917, Public (Joint) Resolution No. 45, Sixty-fourth Congress, became a law. In addition to certain penalty provisions, it provided as follows:

> That the Secretary of War be, and he is hereby, authorized to issue permits, revocable at will, for the diversion of water in the United States from the Niagara River above the falls for the creation of power to individuals, companies, or corporations which are now actually producing power from the waters of said river, in additional quantities which, with present diversions, shall in no case exceed the capacity of the generating machinery of the permittee and tenant companies now installed and ready for operation, nor an amount sufficient to enable the permittee to supply the now existing hydro-electric demands of the individuals, companies, or corporations which said permittee and tenant companies are now supplying, but not in excess of the capacity of power-using appliances of said consumers now installed and ready for operation: Provided, that in no event shall the total quantity of water diverted in the United States from said river above the falls for power purposes exceed in the aggregate a daily diversion at the rate of twenty thousand cubic feet per second, And provided further, that this resolution shall remain in force until the first day of July, nineteen hundred and seventeen, and no longer, at the expiration of which time all permits granted hereunder shall terminate, unless sooner revoked; and nothing herein contained shall be held to confirm, establish, or confer in or upon any such permittee any right in or to the water which he is now diverting or which he may be authorized to divert hereunder.

Immediately upon approval of the resolution (January 19, 1917) the Secretary of War issued "additional" permits to each of the two generating companies on the New York side of the river; the additional permit to The Niagara Falls Power Company (1886) was for a "daily diversion at the rate of 1400 cubic feet per second," to be used with, and in addition to, its diversion at

the momentary maximum rate of 8600 cubic feet per second as formerly fixed by the Burton Law; and to Hydraulic Power Company of Niagara Falls for an additional 3000 cubic feet per second.

Public Resolution No. 8, Sixty-fifth Congress, approved June 30, 1917, extended the term of the preceding resolution (No. 45 of Sixty-fourth Congress) until July 1, 1918.

Under authority of a further joint resolution, approved June 29, 1918, the Secretary of War on July 1, 1918, issued permits to the companies for daily diversions at the rate of 10,000 cubic feet per second by The Niagara Falls Power Company (1886) and 9500 cubic feet per second by Hydraulic Power Company of Niagara Falls. The consolidation of the two companies in October, 1918, into the present The Niagara Falls Power Company (MCMXVIII) merged these permits, which pursuant to a further joint resolution, approved in July, 1919, were extended by the Secretary of War to July 1, 1920.

Both the latter two joint resolutions provided that permits to be issued thereunder should exceed in no event "in the aggregate a daily diversion at the rate of 20,000 cubic feet per second," which limitation, it will be observed, agrees, both in the amount and in the phraseology used, with the provision of the treaty with Great Britain controlling the limits of diversion above the falls for power purposes on the New York side of the Niagara River. The treaty commissioners had recognized the fairness of equalizing through the hours of the day the necessary momentary inequalities of the load of a generating plant in practical operation.

Bills dealing specifically with, or intended permanently to regulate, the diversion of water from the Niagara River for power purposes, were introduced and considered in committee in the sessions of the Sixty-first Congress (1909–1911) and of each succeeding Congress to and including the Sixty-sixth (1919–1921). None of the measures became law until the enactment of the Federal Water Power Act, approved June 10, 1920. That law is general in scope and applies to the situation at Niagara.

WAR REQUIREMENTS

The use of Niagara power in useful productions was in the course of rapid growth in 1906 when the Burton Law was first enacted. The demand for such use very soon outstripped the capacity of the generating plants as restricted by that law. The demand still was increasing rapidly when the entry of the United States into the World War brought it overwhelmingly beyond the capacity of the plants even when operated without harmful restrictions in

water use. Many materials were being produced at Niagara which were indispensable for the winning of the war, and there was no limit, practically, to the demand for power for use in their production.

The responsibility for so critical a power famine may be assigned to the failure of the Congress in enacting timely and adequate legislation permanently regulating the use of water of the river for power production and fixing the status of the generating companies in respect of federal jurisdiction and control.

Subject to assurance of reasonable protection in the additional investment required, both the generating companies then operating at Niagara at all times had been prepared to proceed with the construction of additional plants or to reconstruct existing plants so as to obtain the greatest efficiency in the use of the water diverted.

In response to inquiries of the War Department made in 1913, The Niagara Falls Power Company had stated in a letter to the Chief of Engineers, United States Army, that

> No one can be more desirous of meeting any increased demand for power than will be The Niagara Falls Power Company, the pioneer in the production of hydro-electric energy for industrial use and long-distance transmission whose enterprise preceded any demand for electrical power and antedated any and all legal complications. . . .
>
> Preliminary estimates indicate the possibility of supplementing the present works of The Niagara Falls Power Company so as to utilize to the utmost practicable extent, between its intake and outlet, the potentiality of the waters by it diverted from the river . . . . To this end, however, an absolutely essential prerequisite would be the approval of the Federal Government of the right to use the water permanently, or for an adequate period, and under conditions promising a fair return on such investments.

Later in replying to further inquiries of the War Department, in 1916, when the prices of the required material and labor had advanced approximately 50 per cent, that company had further stated in a letter to Major H. Burgess of the United States Lake Survey, dated September 30, 1916,

> Subject to confirmation by the Federal Government of our rights for the necessary water diversion for such a term and upon such conditions as will render it practicable to raise the required money, we shall be ready and would like to undertake the work as soon as the present abnormal conditions of the labor and material markets are adjusted to a basis that will permit the project to be carried out with due regard to economic considerations.

GOVERNMENTAL REQUISITION OF ENTIRE PRODUCTION

It soon became necessary to use all the available power for industries most essential in the conduct of the war.

The President of the United States, by orders signed by the Secretary of War under date of December 28, 1917, requisitioned the total quantity and output of electrical power produced or capable of being produced by the two generating companies at Niagara Falls, New York, as well as the power transmitted into the United States from Canada.

Thereafter until the release of the requisition at midnight of November 30, 1918, all electricity generated in the plants of the two companies and all transmitted into the United States from Canada was controlled and distributed under the direction of General Keller and Mr. Robert J. Bulkley, acting, through the War Department, for the President of the United States.

CONSOLIDATION OF COMPANIES AND ADDITIONAL DEVELOPMENT AS A WAR MEASURE

Disregarding the neglect of the Congress up to the time to provide for permanent permits and trusting to final recognition of the equities in the case, the New York generating companies early in the spring of 1918, undertook at the solicitation of the War Department and the President's power administrators, to agree upon terms of consolidation and with their united resources rapidly to install an additional 100,000 horse-power generating plant for expected use in helping in the conduct of the war. General Benedict Crowell, then Acting Secretary of War, approved the plans, his letter of April 5, 1918, addressed to Hydraulic Power Company of Niagara Falls stating:

> It is my understanding that you will immediately proceed to combine your interests with those of The Niagara Falls Power Company and the Cliff Electrical Distributing Company, and that the reorganized corporation will commence the work immediately and prosecute it diligently.
>
> The importance to the Government of having additional power available for delivery as soon as may be is well known to you, and I hope and believe that you will leave nothing undone to complete this development at the earliest possible time.

The new installation was begun forthwith and negotiations between the officers of the companies involved resulted in consolidation (under agreement dated September 20, 1918) into The Niagara Falls Power Company (MCMXVIII).[1]

THE FEDERAL WATER POWER ACT

On June 10, 1920, the President approved of the act of Congress known as the Federal Water Power Act, substantially in the form prepared under direction of members of the Cabinet of President Wilson and submitted in

[1] The Roman numerals (MCMXVIII) while not part of the legal title serve to distinguish the company from its constituent corporation of the same name of 1886 and have been incorporated in the corporate seal of the consolidated company

1919 to the Sixty-fifth Congress by the President with a recommendation for its enactment.

During debates on the floor of the House, both in the last session of the Sixty-fifth and in the first session of the Sixty-sixth Congress, motions had been made to amend the measure by excluding from its provisions boundary streams. The debate indicated that the amendments were particularly intended to make the bill inapplicable to the use of the water of the Niagara River by the generating companies on the New York side of that stream. Both motions were defeated and the bill as it passed the House applies to the New York side of the Niagara equally with other navigable rivers in the United States.

The measure as passed and approved by the President, among other things, most of which are not particularly applicable to the Niagara situation, provides in substance:

(1) For a Federal Water Power Commission, composed of the Secretaries of War, the Interior, and Agriculture.

(2) For licenses to be issued by the commission for periods not exceeding fifty years to develop and utilize power in or from navigable waters of the United States.

(3) For a reasonable annual charge to be fixed by the commission and paid by the licensees.

(4) For comprehensive regulatory powers to be exercised by the commission.

(5) For preferential consideration, in the granting of permits, of applications by states and municipalities provided their plans are equally adapted to conserve and utilize, in the public interest, the navigation and water resources of the region.

(6) For the establishment of amortization reserves to be applied to the reduction of the amount of the licensees' net investments.

(7) For "recapture" by the United States at the end of the term of the permit, but on not less than two years' prior notice to the licensee, and on payment of the fair value of the property taken and reasonable damages caused by the severance therefrom of property dependent thereon and not taken, such values and damages not to include or to be affected by the value of any lands or property of the United States licensed under the provisions of the act, or by good will, going value or prospective revenues, nor are the values allowed to be in excess of the actual reasonable cost.

(8) For the optional issue by the commission at the end of the term, in cases where the United States does not take over the project, of a new license to the original licensee upon such terms as may then be authorized by law, or the issue of such new license to a new licensee, who shall make the same payments to the original licensee and assume the same obligations as the United States would have been required to make and assume, if it had taken over the project.

(9) In cases where the United States does not take over the project and a new license is not issued, the commission shall issue from year to year to the licensee an annual license under the terms and conditions of the original license until such time as the property is taken over or such new license issued.

(10) The Federal Government may at any time when, in the opinion of the President, the safety of the United States so demands, take over the project for the purpose of manufacturing nitrates, explosives, or munitions of war, or for any other purpose involving the safety of the United States, with provisions for the restoration of the property unimpaired at the end of any such period and the payment of just and fair compensation for its use.

The Federal Water Power Act afforded a basis for disposing of the Niagara power question—a subject of debate on the floor and in committees of Congress since the time of President Roosevelt's message on "The Preservation of Niagara," of March 27, 1906, failure to settle which had substantially hindered the progress of extensive beneficial industries and in a considerable degree lessened the preparedness of the nation for the World War. The settlement thereby effected has contributed largely to the success of the era of heightened production so necessary for the welfare of this country and the exhausted nations of Europe.

FEDERAL WATER POWER COMMISSION

Upon application by the company, the Federal Water Power Commission on March 2, 1921, pursuant to authority vested in it by the Congress in the Federal Water Power Act, licensed (its license No. 1) The Niagara Falls Power Company (MCMXVIII) "to construct, operate and maintain diversion structures, water conduits, power-houses, transmission lines, and other project works, and to develop, transmit, and utilize power from the waters of the Niagara River as described in *** application."

The license sets forth at considerable length the terms upon which it was granted, which include, among others:

(1) Authority to the company for a term of fifty years "to divert, within the State of New York, from the waters of said Niagara River, above the falls of Niagara, for power purposes, water not exceeding in the aggregate a daily diversion at the rate of 19,500 cubic feet per second, provided that the maximum diversion in any calendar day shall not exceed said rate by more than twenty per cent thereof."

(2) Definite fixed dates for beginning and completing the unconstructed portion of the project works.[1]

(3) The water to be diverted by the licensee may be utilized in its power stations heretofore built in the city of Niagara Falls, New York, until the licensee shall construct its "Proposed Addition to Station No. 3 Extension Hydraulic Plant" and as soon as

[1] Specifications of dates for commencement and completion of construction were fully complied with.

a new unit or units of its said "Proposed Addition to Station No. 3 Extension Hydraulic Plant" shall be installed and ready for operation, the licensee shall utilize the water so authorized to be diverted by it, in the operation of its plants in such manner as shall produce the best results, it being intended after the completion of "Proposed Addition to Station No. 3 Extension Hydraulic Plant" that the existing Niagara plant shall be maintained and operated as a reserve, emergency, or peak load plant, or be operated with any increased diversion which the licensee may hereafter be legally authorized and entitled to divert from the Niagara River for power development.

(4) The licensee to pay to the United States annual charges determined as provided in the regulations theretofore adopted by the Federal Power Commission. (These charges now (1925) amount to 25 cents per horse-power per year on an output computed under a general formula adopted by the commission.)

(5) Certain provisions for depreciation and amortization of the net investment in the project and the establishment and maintenance out of surplus earnings of certain amortization reserves.

(6) Observance of all terms and conditions provided in the Federal Water Power Act in respect to licenses issued thereunder, including the provision for recapture of the project works.

The Boundary Waters Treaty between the United States and Great Britain, proclaimed May 13, 1910, limits the amount of water that may be diverted on the New York side of the Niagara River, above the falls, to 20,000 cubic feet per second. While the treaty remains in force, unamended, its limitations are controlling on the Congress and the latter's empowered agent, the Federal Water Power Commission. Of the allowable 20,000 cubic feet per second on the New York side, all but 500 cubic feet per second was granted to The Niagara Falls Power Company for a term of fifty years from March 2, 1921. That amount of water is now fully used at the highest attainable efficiency under the full available hydraulic head between the place of diversion and where the water is returned to the river immediately below the American Fall. An additional 225 cubic feet per second of the 500 cubic feet per second also is in use under terms of a temporary supplemental license, which it is expected will be made for the full term of the original license.

The electric energy generated by use of the granted water is employed in useful industries or in public service throughout the considerable part of the State of New York served by the company or by service companies supplied directly or through transmitting companies. Due to the fact that Niagara energy is furnished at prices much lower than the cost of steam power and to other distinct advantages in use, there still remains an insistent demand for its supply on the Niagara frontier and elsewhere where it can be economically transmitted.

In view of the fact that with, or even without, easily installed remedial measures, much more water could be diverted around the cataract without impairing the scenic features of the river and falls, it is obvious that continuance of the present limitations of the Boundary Waters Treaty, unamended, will result in great economic waste, depriving the industries and communities of an important section of the United States of their heritage of power so richly bestowed by nature.

Part IV

CANADIAN NIAGARA POWER COMPANY, LIMITED

INCORPORATED BY SPECIAL ACT OF PROVINCE OF ONTARIO

Lease by Commissioners of
Queen Victoria Niagara Falls Park

1892–1925

THE RIGHTS OF CANADIAN NIAGARA POWER COMPANY, LIMITED

The Canadian Niagara Power Company, Limited, the entire capital stock and all funded obligations of which are held by The Niagara Falls Power Company, was incorporated by a special act[1] of the Legislative Assembly of the Province of Ontario, Canada.

Its generating station, including water-intake, power-house, and tail-race discharge tunnel, is located in Queen Victoria Niagara Falls Park which fronts on the Niagara River at Niagara Falls, Ontario.

The lands occupied and water-rights are leased to the company by the Province of Ontario under an agreement dated April 7, 1892, executed by and between the commissioners of the Queen Victoria Niagara Falls Park and Albert D. Shaw, Francis Lynde Stetson and William B. Rankine. This lease with certain amendments was confirmed by a further special act[2] and the original lease has been amended by subsequent agreements executed by the commissioners of the park and by the company and confirmed by acts of the Ontario Legislative Assembly.

The lease ("agreement") herein referred to, *inter alia,* provides:

(1) For the purpose of generating electricity and pneumatic power to be transmitted to places beyond the park, the commissioners grant to the company a license irrevocable save as therein limited to take water from the Niagara River at certain specified places, and lead such water . . . to supply works to be erected and constructed by the company in buildings and power-houses at a specified location on the mainland within the park . . . which location shall occupy a tract of land of not more than 1200 feet in length by not more than 100 feet in width.

(2) The company shall have the further right to excavate tunnels to discharge the water led from the Niagara River to the said buildings and power-houses so that such water by means of such tunnels shall emerge below the Horseshoe Fall at or near the water's edge of the Niagara River.

The original lease provided for a term of twenty years beginning with May 1, 1892, and was renewable at the option of the company for four additional successive terms of twenty years each.

[1] 55 Victoria, Chapter 8, assented to 14th April, 1892.

[2] 62 Victoria, Chapter 11, Section 35, assented to 1st April, 1899.

The amended agreement dated July 15, 1899, provides that the rent to be paid by the company from and after May 1, 1899, up to May 1, 1949, shall be at the rate of $15,000 per annum, and in addition thereto one dollar per annum "for each electrical horse-power generated and used, and sold or disposed of" over 10,000 horse-power up to 20,000 horse-power, and seventy-five cents for each such horse-power over 20,000 horse-power up to 30,000 horse-power, and fifty cents for each such horse-power over 30,000 horse-power. After May 1, 1949, the same rentals are to continue unless readjusted as provided in the agreement.

The amended agreement provides for three successive twenty-year renewals, beginning with May 1, 1949, and that the Lieutenant-Governor-in-Council not less than three years prior to the expiration of the last of such renewals, on notice to the company, may require the company to continue its operations for a further period of twenty years.

It will be noted that any limitation on power production of the tenant company imposed by provisions of the lease is not in terms of water or power produced but is covered by location, size and character of water-intake, discharge tunnel, turbines, generators, and other essential plant as approved by the park commissioners. The works so approved include (1925) ten generating units and one spare unit, having an aggregate rated capacity of 121,000 horse-power.

The rent paid in 1925 to the park commissioners amounted to $67,003.29.

Operation under the lease is somewhat complicated by the fact that the government of the Dominion of Canada has jurisdiction of power exportation and some authority under the Boundary Waters Treaty of 1909 which limits the aggregate quantity of water that may be diverted for power purposes within the Province of Ontario from the Niagara River above the falls.

Of the total power produced by the Canadian Niagara Power Company, Limited (1925), about 50,000 horse-power is ordinarily transmitted to the international boundary for exportation into the State of New York; about 30,000 horse-power is sold and delivered direct to industries in the Province of Ontario; and 20,000 horse-power is sold and delivered to the Hydro-Electric Power Commission of Ontario (an administrative department of the Provincial Government).

In the year 1907 the Dominion of Canada passed the Electricity and Fluid Exportation Act (6–7 Edward VII, Chapter 16), and since that time the Department of Trade and Commerce of the Dominion of Canada has continued from year to year to issue to the Canadian Niagara Power Company, Limited, an annual license to export or sell for export from Canada electrical

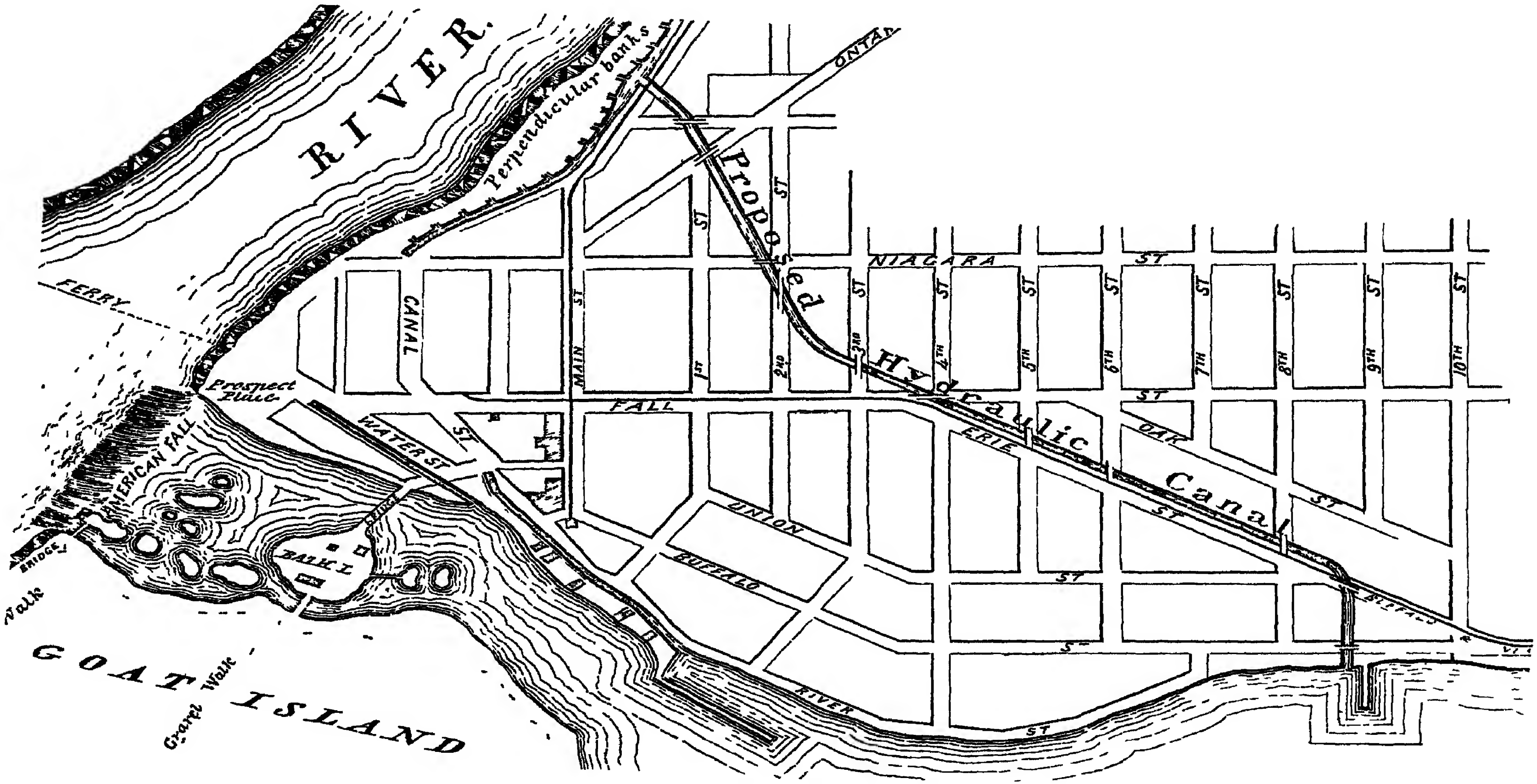
energy at a rate not exceeding during the year the rate specified in the license. The company now (1925) has two such export licenses which run concurrently; one for 45,000 kilowatts (60,000 horse-power) and the other for an additional 20,000 kilowatts. The additional license provides that all or any part of the electrical energy exported thereunder shall be subject to recall on demand for delivery in Canada.

On March 16, 1925, acting under the authorization of Section 10 of the Electricity and Fluid Exportation Act already referred to, an Order-in-Council was passed by the Dominion Government imposing an export duty of three one hundredths of a cent ($0.0003) per kilowatt hour upon power exported from Canada; said duty to be in addition to any fee payable for a license for the exportation of power and to be payable in respect of power exported on and after the first day of April, 1925. The duty paid by the Canadian Niagara Power Company, Limited, in 1925 (9 months) amounted to $72,005.15.

THE CATARACT CONSTRUCTION COMPANY ORGANIZATION, OPERATION, LIQUIDATION AND DISSOLUTION

1889–1909

Chapter XII



MAP OF NIAGARA FALLS AND VILLAGE

By P Emslie, December, 1846

THE CATARACT CONSTRUCTION COMPANY ORGANIZATION, OPERATION, LIQUIDATION AND DISSOLUTION, 1889-1909

CHAPTER XII

ORGANIZATION

THE Cataract Construction Company was incorporated June 13, 1889, under the general laws of the State of New Jersey, by Francis Lynde Stetson and associates, Edward A. Wickes and William B. Rankine, as a means for carrying out certain power developments at Niagara Falls which they had under consideration. They were then negotiating for the purchase of a charter and other rights and property relative to such developments and particularly the capital stock of the so-called Gaskill company that controlled the project of Thomas Evershed for the development of power at Niagara.

Among its objects, the company was authorized to carry on the business of making and letting of contracts to build works of improvement of any kind, whether railroads, viaducts, aqueducts, dams, tunnels, conduits, reservoirs, raceways, mills, manufactories, pipe-lines, cable systems, electric systems or hydraulic systems.

An amendment specified that its principal office outside of the State of New Jersey would be situated in the city and county of New York, in which place, as well as at Niagara Falls in the county of Niagara, and Buffalo in the county of Erie, all in the State of New York, the company proposed to carry on operations.

Although the primary object of the company, as indicated by its name, purposes and locations, was to enter into a contract with the Niagara River Hydraulic Tunnel, Power and Sewer Company[1] for the performance of work of construction at Niagara Falls, yet it had legal power to engage in other undertakings.

This power company[2] was organized particularly to utilize Niagara waters for power purposes in conformity with a project, prepared therefor by Thomas Evershed, and acquired for this purpose by the company. The negotiations for the purchase of the shares of this newly organized power company were prompted by the fact that their ownership would include the plans and estimates prepared by Mr. Evershed, who was then a director in the company and its chief engineer.

[1] Name changed to The Niagara Falls Power Company in 1889.

[2] See Chapter VII, The Evershed Scheme, Niagara River Hydraulic Tunnel, Power and Sewer Company, 1886.

PURCHASE OF THE NIAGARA FALLS POWER COMPANY

Over three years had now elapsed since March, 1886, when the Niagara River Hydraulic Tunnel, Power and Sewer Company obtained from the State of New York its special charter, with authority to take an unlimited quantity of water from Niagara River for power and other purposes, and to acquire lands and franchises in such developments. Great activity was manifested by the officers and directors of this power company to secure the necessary capital to finance their enterprise, by the sale of stock and later by the sale of first mortgage bonds, both of which were offered, unsuccessfully, in the leading financial centers of this country and the bonds in London. In the course of such negotiations the project had been presented to Francis Lynde Stetson, lawyer, of New York City, who manifested some interest in the enterprise and pursued, with a few associates, several lines of investigation that led to his obtaining an option to purchase the entire capital stock of the company.

This option was not availed of and its term lapsed without action. After nearly a year of study of some of the legal, business and engineering questions involved in the project, it was decided in 1889 by the Stetson associates in the organization, to proceed with the enterprise as a hydraulic power proposition, differing from those in New England in its magnitude and the methods of development necessitated by the location of the falls and the city, at the angle of the Niagara River.[1] Negotiations were resumed in the spring of 1889 and a contract was made by The Cataract Construction Company, organized expressly for this purpose, with the stockholders of the Niagara company to purchase all their shares. The cataract company entered into a preliminary agreement with the Niagara company, under date of July 5, 1889, for the construction of its hydraulic plant in consideration of its capital stock and bonds to be issued in payment therefor.

Further agreements were executed between the two companies as the project developed, under which the cataract company became the representative of the Niagara company, charged with the designing, financing and constructing of the plant.

Pursuant to the definite plans adopted during 1889 and 1890, an important area of land was acquired by the cataract company, favorably located for the development of the power enterprise.

On December 31, 1890, The Cataract Construction Company offered to sell and transfer to the Niagara company all its lands in the town of Niagara, consisting of 1237 acres (1200 upland and 37 under water) at a

[1] See Chapter VIII, The Evershed Tunnel Project, Investigation and Modification, 1889–1890

valuation of $2,437,000, payable in $1,996,400 par value of 19,964 shares, being the whole capital stock authorized, less the qualifying shares of the directors of the Niagara company, together with $440,000 par value of bonds of the Niagara company. This proposal was accompanied by numerous appraisals of the lands by local and other experts familiar with the property. The proposal was accepted by the terms of a fourth Niagara-cataract contract, that was then authorized to be executed.

Further investigations followed an invitation to financial interests to join the cataract group and a formal agreement was made in lieu of the preliminary agreement of July 5, 1889, with the Niagara company.

By an agreement of January 17, 1890, a "stock subscription" was made to an increase of 400 shares of the capital stock of The Cataract Construction Company at its par value of $50 per share, and a "money subscription" was also made to $2,900,000 of the proposed first mortgage bonds of The Niagara Falls Power Company at 90 per cent of their par value, constituting a total cash subscription for the purposes of The Cataract Construction Company of $2,630,000.

The agreement provided that any and all profits received or realized by the cataract company in the performance of its construction contracts should go and belong to that company and all the stockholders thereof would share pro rata therein according to the number of shares held by them.

The bonds as earned and received from the Niagara company were to be deposited with a committee of three persons appointed by a majority in interest of the money subscribers, said committee being empowered to hold, manage and sell the bonds for account of the subscribers.

LEGALITY OF PROCEEDING OF CATARACT COMPANY

Prior to the execution of the agreements and contracts of The Cataract Construction Company of July 5, 1889, legal opinions concerning the charters of the Niagara River Hydraulic Tunnel, Power and Sewer Company and of The Cataract Construction Company, and the contracts between the Niagara and cataract companies, and the Niagara stockholders and the cataract company, were furnished to persons in interest.

The opinion of Francis Lynde Stetson of June 13, 1889, concludes as follows:

> I am of opinion that the Niagara company and its intending contractors may enter into a construction contract, as before indicated, for stock and bonds containing proper provisions waiving all individual liability of stockholders and bondholders.

Victor Morawetz, in his letter of July 1, 1889, referring to the afore-described documents, stated:

I am of opinion that no liability would result from the issue of stock and bonds as proposed.

Charles E. Tracy stated July 3, 1889, that he had "examined the foregoing papers and opinions of counsel and concurs in the views expressed by them."

ORGANIZATION OF SUBSCRIBERS AS STOCKHOLDERS

At the meeting of subscribers, February 6, 1890, for the purpose of completing organization, it was recommended that The Cataract Construction Company should

increase to eleven its board of directors, then consisting of:

Francis Lynde Stetson
Edward A. Wickes
William B Rankine

by the election of eight additional directors, viz:

Edward D. Adams
George S. Bowdoin
Charles F. Clark
A. J. Forbes-Leith
Walter Howe[1]
Charles Lanier
D. O. Mills
Frederick W. Whitridge

and an executive committee composed of:

Walter Howe
Charles Lanier
D. O. Mills
Francis Lynde Stetson
Frederick W. Whitridge

It was also recommended to elect the following officers:

President	Edward D. Adams
Vice-presidents	Francis Lynde Stetson Edward A. Wickes
Secretary	William B. Rankine
Treasurer	George H. Kent

It was further recommended to appoint as committee of bankers, representing "money subscribers" under Subscription Agreement of January 17, 1890

George S. Bowdoin, of Drexel, Morgan & Company
John Crosby Brown, of Brown Brothers & Company
Charles Lanier, of Winslow, Lanier & Company

[1] Died in 1890; succeeded by Joseph H. Larocque.

and to proceed with the preparation, execution and performance of a contract with The Niagara Falls Power Company as contemplated in the agreement of January 17, 1890.

At a meeting of the cataract stockholders, action was taken as requested by the "money subscribers."

The first board of directors, just named, comprised eleven stockholders representing nearly all the capital stock of The Cataract Construction Company. They were responsible pioneers of the newly formed enterprise, closely united in a purpose, and themselves serving as voussoirs of a system, as in a true arch[1] that, as they say in India, "never sleeps," where all stones are of equal importance, each supporting its burden, interlocking firmly although differing in form while similar in substance, and all co-operating as a unit. Such were the first directors and their successors, in all twenty-one different persons, serving as directors and officers during twenty-nine years of the undertaking.

With the exception caused by the removal of residence permanently to England, and several withdrawals on account of ill health, no director resigned his office, and otherwise death alone permitted the selection of new associates upon the company's board.

At the annual meeting, June 4, 1901, of the stockholders of The Niagara Falls Power Company, the number of directors was increased to thirteen, at which number it remained. The board of directors then elected consisted of the following stockholders:

Edward D. Adams	Darius O. Mills
John Jacob Astor	Victor Morawetz
George S. Bowdoin	Daniel O'Day
Charles F. Clark	William B. Rankine
Charles Lanier	Francis Lynde Stetson
Joseph H. Larocque	Frederick W. Whitridge

Edward A. Wickes

The personnel of the board of directors of The Cataract Construction Company and of The Niagara Falls Power Company, into which latter the directors of the former were elected upon the completion of their construction undertaking, was changed from time to time by elections to fill vacancies, so that on September 20, 1918, the date of the joint agreement of consolidation with the Hydraulic Power Company of Niagara Falls, the board of directors

[1] See end of this chapter.

of The Niagara Falls Power Company that surrendered its control to the owners of the hydraulic company was as follows:

ORIGINAL DIRECTORS OF 1890
REMAINING IN 1918

Edward D. Adams
Charles Lanier
Francis Lynde Stetson

ADDITIONAL DIRECTORS ELECTED TO FILL VACANCIES

Nicholas Biddle
Charles D. Dickie
Le Grand S. De Graff
Ogden Mills
Victor Morawetz
Robert W. Pomeroy
De Lancey Rankine
Carlton M. Smith
Edward T. Stotesbury

OFFICERS
THE NIAGARA FALLS POWER COMPANY

Stacy C. Richmond, President and Director
Philip P. Barton, Vice-president and General Manager
Frederick L. Lovelace, Secretary
W. Paxton Little, Treasurer

CANADIAN NIAGARA POWER COMPANY, LIMITED

A. Monro Grier, President

ADDITIONAL LEGISLATION

The novel methods necessarily adopted in the introduction of central power stations, inlet-canals, and discharge tunnels, also in the acquisition of the rights-of-way for electric power transmission lines, over, across and under the Erie Canal and public thoroughfares, required the exercise of corporate powers not provided in the general laws of the State of New York. A special law had been enacted by the legislature to meet these requirements so far as they could be anticipated in 1886. As additional powers were seen to be necessary, amendments to the original special act were granted and the public approved of these encouragements to the company, the success of which meant so much to the prosperity of the community.

FIVE AGREEMENTS BETWEEN THE CATARACT CONSTRUCTION COMPANY AND THE NIAGARA FALLS POWER COMPANY

The relations between The Cataract Construction Company and The Niagara Falls Power Company were prescribed by five agreements, executed

on and between July 5, 1889[1] and April 27, 1891. They were occasioned by the same reasons for which the charter of The Cataract Construction Company was amended about six months after its original filing in 1889. The charter of The Niagara Falls Power Company of March 31, 1886, was amended five times, the last on April 25, 1893, and the permits issued by the Superintendent of Public Works of the State of New York, under which the transmission line to Buffalo was established, constituted a series of seven official certificates authorizing action, beginning August 30, 1895, and approving assignment of the completed line, October 14, 1898, to the Cataract Power and Conduit Company of Buffalo.

The activities of the group of pioneers operating at Niagara Falls from 1889 to 1898 were manifested in the aforedescribed documents. They indicated advances in the development of the enterprise, in the solution of the Niagara problem, the introduction of new agencies for power development and use affecting the interests of a large population and prompting state and municipal legislation to protect the people and at the same time to encourage the promoters in their original work, that promised much to industries, values, taxation and civilization.

The five agreements between the cataract and Niagara companies placed grave responsibilities upon the cataract company, which became the agent of the Niagara company. Upon it devolved the scientific investigations, the adoption of new systems of engineering, the selection of wise and experienced advisers and assistants, and the provision of a large amount of capital for the proper development of the great work undertaken.

PURCHASE OF FILIAL COMPANIES

The Cataract Construction Company, acting upon the authority granted by the amendment to its charter, to acquire and administer the securities of other companies affiliated in interest with the objects of the cataract incorporation, had purchased, by the terms of its agreement of July 5, 1889, with The Niagara Falls Power Company and its stockholders, the entire capital stock of that company. It later acquired the entire capital stocks of the following companies:

Lewiston Water Supply Company

> Organized under a special charter from the State of New York giving exclusive rights to take water from the Niagara River for power and other purposes. This company owned the report and plans of J. T. Fanning for power development at Niagara

[1] See page 234.

on a grand scale. No action was taken under this charter, which expired in 1893 by limitation.

Niagara Falls Water-Works Company

Organized under the general laws of the State of New York and engaged in supplying potable water to the city and citizens of Niagara Falls under a contract with that municipality. This company was expanded in its resources and business, and was subsequently acquired by the Girard Trust Company of Philadelphia, for account of the Western New York Water Company.

Niagara Junction Railway Company

Organized, financed and its property constructed by the cataract company, which retained a majority of its capital stock.

Niagara Development Company

Organized, financed and its property improved by the cataract company, which held a majority of its capital stock, that was subsequently exchanged for shares of The Niagara Falls Power Company, the parent company.

Canadian Niagara Power Company

Organized under a special charter granted by the Government of the Province of Ontario, Canada, to develop power within the Queen Victoria Niagara Falls Park from the waters of Niagara River under terms of rental for use of a prescribed area. The control of 60 per cent and later the balance of the capital stock were acquired.

Four optional agreements were approved between the Niagara company and Frank W. Hawley, of Pittsford, New York, providing for the transmission of electrical power to Rochester, Syracuse, Utica, Albany and points between. These agreements were assigned to the Cataract General Electric Company, organized by Mr. Hawley and his associates for this purpose.

The officers of the company were authorized to make similar contracts for the delivery of electrical power in Lockport, Wheatfield, Tonawanda and North Tonawanda.

These agreements were designed to encourage experimental work by Mr. Hawley and his associates, and to determine the general terms upon which they might rely, should they succeed in their negotiations and desire a contract for the purchase of electrical power for transmission and distribution. These efforts were not successful.

TRANSMISSION FRANCHISES AND CONSTRUCTION PLANS

In the meantime the organization of The Cataract Construction Company had been completed and preparation for construction was being pushed forward with an expansion of the plans and objects. The great strides being made in all things pertaining to hydro-electric development stimulated the minds of all concerned, and, in the winter of 1891, it became evident that recourse should again be had to the law-makers of the state, especially for enlarged powers in the means of transmission, for extension of the territory within which electricity could be transmitted, and for further rights of the company therein.

The line of the main tunnel was determined September 12, 1890, by The Niagara Falls Power Company under the terms of its contract of April 1, 1890, with The Cataract Construction Company:

> Beginning with the opening or portal at the water edge below the upper Suspension Bridge on lands lately owned by Jane S. Townsend and extending thence under the village of Niagara Falls in a straight line southeasterly 6700 feet more or less to the lands on the Niagara River lately owned by Myron H. Kinsley, with shaft sites (1) at the junction of Falls and Erie streets in said village, and (2) lots numbers 8, 10, 12 and 14 Tenth Street, according to the plans on file in the office of this company at Niagara Falls.

The sub-contract of The Cataract Construction Company for the construction of the first section of the work was approved September 12, 1890.

LIQUIDATION AFTER TEN YEARS OF ACTIVITY

The activities of The Cataract Construction Company continued for ten years as the agent and attorney of The Niagara Falls Power Company, until, upon the demonstration of success of the engineering plans adopted, including the transmission of electric power to Buffalo, the cataract company surrendered its undertaking and withdrew from active operations, the Niagara company taking over the entire management of the property, and the officers of the cataract company assuming their relative positions in the Niagara company. (The cataract company held its capital intact for use in case of need by the Niagara company until 1910, when it liquidated and surrendered its charter.)

MUTUAL RELEASES

An agreement was entered into under date of May 31, 1899, between The Cataract Construction Company and The Niagara Falls Power Company, cancelling the five construction contracts existing between them and creating mutual releases by each company to the other. The execution of this agreement was approved by the stockholders of both companies, and proceedings

were taken to effect a final and complete settlement, adjustment and termination of all contract relations between the two companies.

ELECTION OF CATARACT DIRECTORS AND OFFICERS TO BOARD OF THE NIAGARA FALLS POWER COMPANY

The relations between The Cataract Construction Company and The Niagara Falls Power Company had been established from time to time by mutual contracts as the desirability therefor arose. Many difficult problems had been sufficiently solved after the ten years of activity to justify definite action by The Niagara Falls Power Company in the adoption of a program of capitalization, with share and bond issues that would provide sufficient resources for its financial requirements.

In order to give the enterprise, at the concluding stage of its construction, the credit that it was entitled to receive and might need in its finance and distribution of securities, by publicly associating with The Niagara Falls Power Company the names of its original owners, as an indication of its strength upon which intending users of its power development might confidently rely, it was decided to replace the local trustees at Niagara who sold their interests to The Cataract Construction Company in 1890, by the election to the board of The Niagara Falls Power Company the directors of The Cataract Construction Company who had represented the ownership that would thereafter alone be responsible for the construction and management.

The annual meeting of the stockholders of The Niagara Falls Power Company, on June 6, 1899, was therefore availed of to make these changes in its official organization. The directors and officers of The Niagara Falls Power Company elected at that time were as follows:

OFFICERS

President
Darius O. Mills

First Vice-president
Edward A. Wickes

Second Vice-president and Treasurer
William B. Rankine

Secretary
F. L. Lovelace

Assistant Secretary and Assistant Treasurer
W. Paxton Little

DIRECTORS

Edward D. Adams
John Jacob Astor
George S. Bowdoin
Charles F. Clark
Charles Lanier
Joseph H. Larocque
Darius O. Mills
William B. Rankine
Francis Lynde Stetson
F. W. Whitridge
Edward A. Wickes

EXECUTIVE COMMITTEE

Edward D. Adams	Francis Lynde Stetson
Charles Lanier	Darius O. Mills
F. W. Whitridge	

At this time it was ordered that the

First Vice-president have charge of the New York office, and that the

Second Vice-president have charge of the Niagara office, and make the same his headquarters·

that the books of the company be kept at the Niagara office, and that there be kept in the New York office summarized accounts from which statements could be made at any time of the financial condition of the allied companies, their earnings, income and condition.

REVIEW OF ACTIVITIES

At a meeting of the directors, December 20, 1899, called for the purpose of closing the affairs of The Cataract Construction Company, it was recorded in the minutes that

this board reviews with satisfaction its work of construction now completed under contracts with The Niagara Falls Power Company. In the important preliminary investigations here and abroad, of the many and novel questions arising in connection with the plans for the development of Niagara power; in the strengthening of the power company's comprehensive corporate rights and franchises; in the judicious conduct, during the past ten years, of its various works of construction; in the attracting of many important industries now using that power, and in the accomplishment of a successful transmission of power to Buffalo, this board recognizes and desires officially to acknowledge its deep sense of obligation for the valuable services rendered to it and to the company, without salary, by its first vice-president, Francis Lynde Stetson, whose able counsel, executive ability and continuous devotion to its interests have contributed so largely to the success of the Niagara enterprise.

It was

Resolved: That the official thanks of the company and of this board are hereby tendered to Francis Lynde Stetson, its first vice-president, for such services, and that this minute be inscribed upon the records of the company.

An engrossed copy of this record was presented to Mr. Stetson, bearing the signatures of all his associate directors and accompanied by an imported salver of old English silver suitably inscribed.

DIRECTORS AND OFFICERS AT LIQUIDATION

Edward D. Adams, President
Francis Lynde Stetson, First Vice-president
Edward A. Wickes, Second Vice-president
William B. Rankine, Secretary and Treasurer
John Jacob Astor
George S. Bowdoin
Charles F. Clark
Charles Lanier
Joseph H. Larocque
Darius Ogden Mills
Frederick W. Whitridge

EXPENDITURE AND ITS INCOME

The circular of The Cataract Construction Company of September 30, 1899, to the subscribers under the original agreement dated January 17, 1890, stated:

> The construction of the principal works of The Niagara Falls Power Company by The Cataract Construction Company has been completed and the several construction contracts between those companies have been terminated and cancelled. The Cataract Construction Company, therefore, is now prepared to go into liquidation and to make distribution among its stockholders of its remaining assets.

At the beginning of the year 1900, The Cataract Construction Company, that had been in full charge of the work since 1890, acting as agent of The Niagara Falls Power Company, initiating development and financing construction, surrendered its authority and proceeded to liquidate its assets for the payment of all liabilities and the distribution of its profits.

At the period of withdrawal of the cataract company from activity in preparation for liquidation and dissolution, the works of the Niagara company consisted of eight power units of 5000 horse-power each, operating under leases of 42,575 horse-power, and producing $100,000 of surplus income over operating expenses and interest charges on about $9,000,000 of bonds issued and outstanding.

In anticipation of possible extensions of the enterprise for which the experience, credit and organization of The Cataract Construction Company might again be useful to the interests of The Niagara Falls Power Company, the corporate organization and the share capital of The Cataract Construction Company were maintained, but without employment, until April 1, 1909,

when the capital, with accrued interest, was distributed to the stockholders and the charter was surrendered to the state.

STOCKHOLDERS AND THEIR CONTRIBUTIONS OF CAPITAL

The Cataract Construction Company's capital stock of $25,000 was all subscribed for and fully paid for in cash at its par value in 1890. This capital was repaid when the charter was surrendered in 1909.

Subscriptions by the stockholders were also made at par for the preferred shares of the Development and Railway companies, that were exchanged ten years thereafter, at par and accrued interest, for $674,000 par value of The Niagara Falls Power Company, at par.

The shareholders received at various times pro rata distributions of the company's surplus earnings, amounting to $264,750 in cash, $250,000 in par value of the first mortgage 5 per cent bonds of The Niagara Falls Power Company, $1,800,000 in par value of its capital stock and the privilege, pursuant to the terms of the original syndicate agreements of 1890, to subscribe to $7,196,000 of The Niagara Falls Power Company bonds at 90 per cent of their par value.

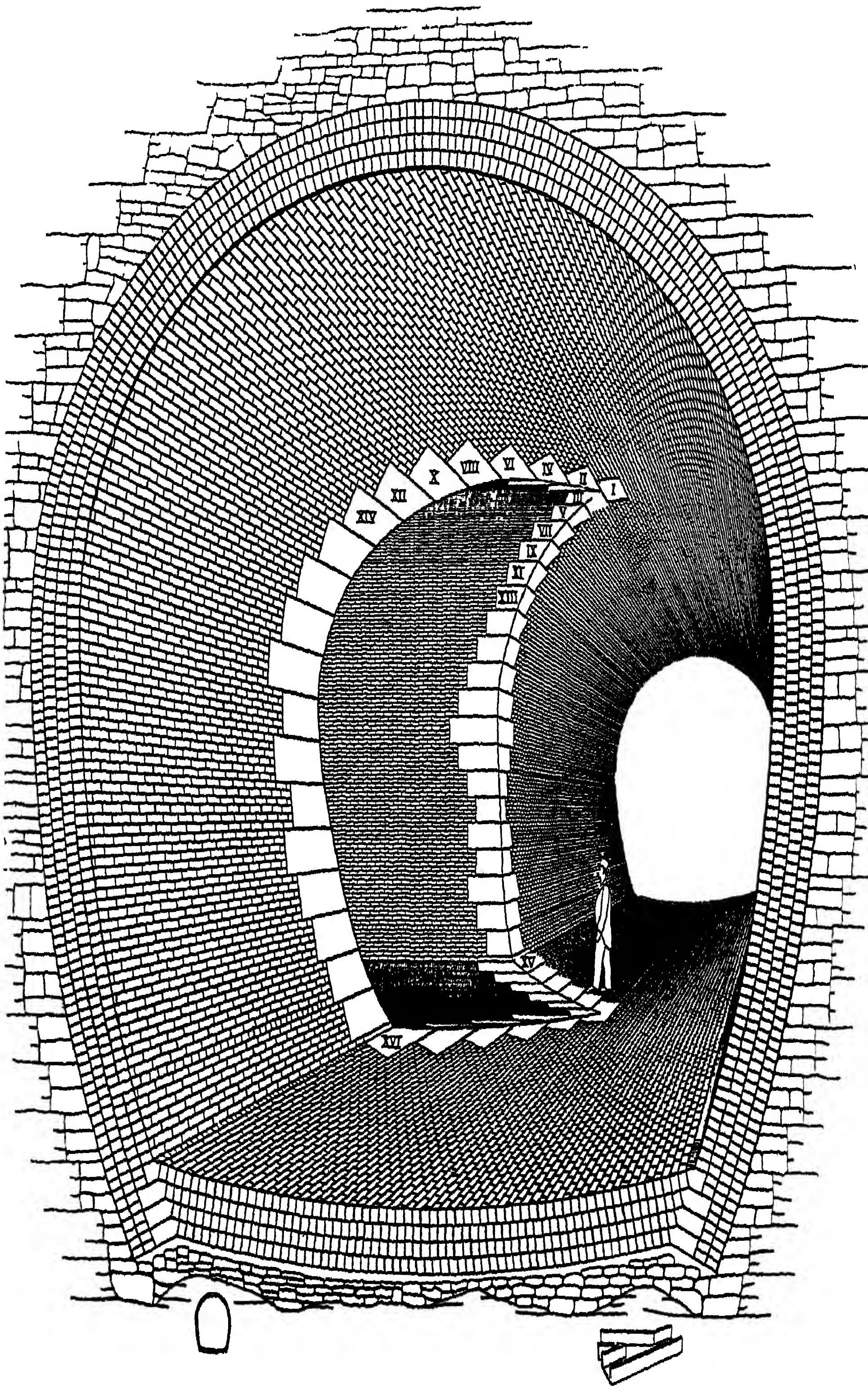
During the years from 1890 to 1900, there was contributed by the stockholders of The Cataract Construction Company, in cash, to the capital funds of the enterprise the total amount of $7,044,500 for which they received in dividends and cash from subscriptions the following securities of

The Niagara Falls Power Company, viz:

$8,832,000 first mortgage 5 per cent bonds

3,974,000 capital stock, par value, and

289,750 cash, equivalent to par or $100 per share for the capital stock, and 31.5 per cent for the par value of the bonds.



Main Tunnel Intersection by Wheel-pit Discharge Tunnel,
Both of Same Size and Form

THE CATARACT CONSTRUCTION COMPANY
THE NIAGARA FALLS POWER COMPANY

PORTRAITS
OF
PIONEER DIRECTORS AND OFFICERS

SUCCESSOR DIRECTORS
AND OFFICERS

CANADIAN PIONEER DIRECTOR
AND PRESIDENT

PERSONNEL
OF CONSTRUCTION AND POWER COMPANIES

In illustrating this chapter with the photographs of these colleagues, it has seemed appropriate to associate their portraits with symbols of their importance in the combination of which they formed the principal part. These symbols are some of the cut granite stones in the arch of the intersection, at an angle of sixty degrees, of the tail-race horseshoe tunnel from the wheel-pit slot under the Power-house Number One, with the main outlet horseshoe tunnel of the same dimensions discharging into the Niagara River. The symbol-stones under the following portraits are numbered to correspond with the numbers on the same stones in the arch on page 246.

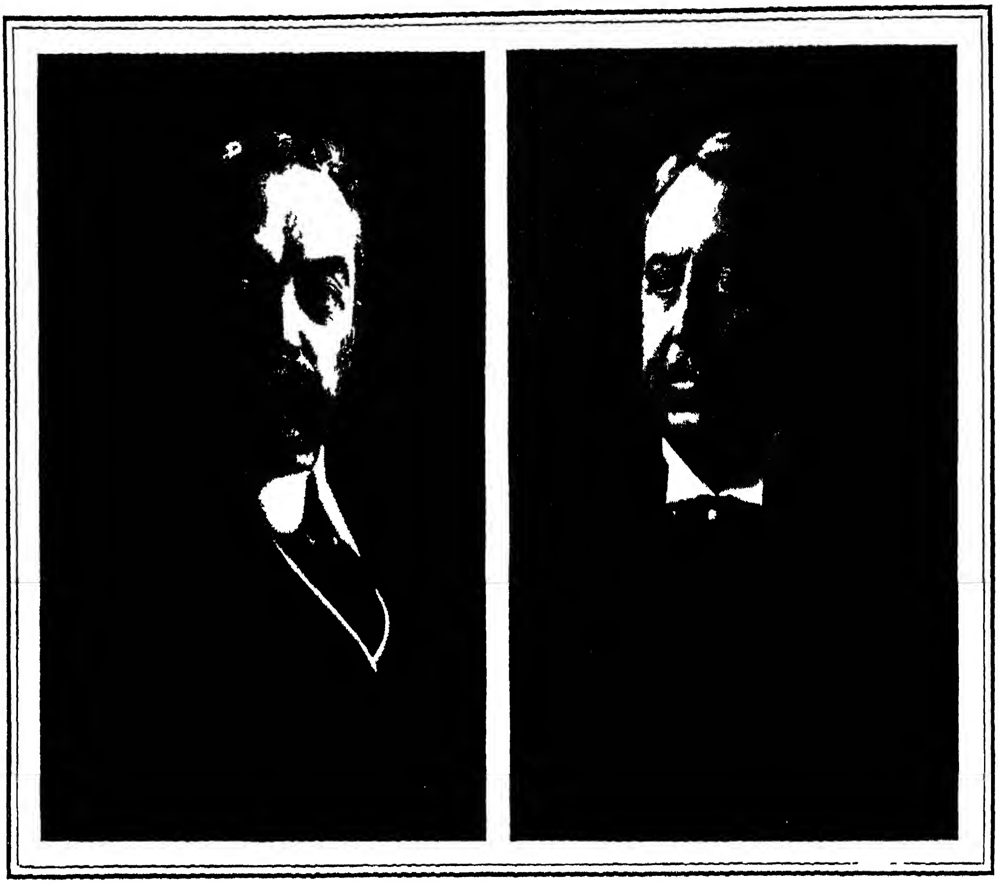
With the exception of the four pioneers that constituted *La Partie Carrée*, the portraits have been grouped as pioneer and successor directors and officers.

Edward Dean Adams	*La Partie Carrée*	*Francis Lynde Stetson
*Edward A. Wickes		*William Birch Rankine

*John Jacob Astor	*George S. Bowdoin
*John Crosby Brown	*Charles F. Clark
*Walter Howe	*Charles Lanier
*Joseph H. Larocque	*Leith of Fyvie
*Darius Ogden Mills	*Frederick W. Whitridge
*Nicholas Biddle	Le Grand S. De Graff
*Temple Bowdoin	Arthur H. Masten
*Charles D Dickie	Ogden Mills
Victor Morawetz	Robert W. Pomeroy
De Lancey Rankine	*Stacy C. Richmond
*Carlton M. Smith	E. T. Stotesbury
*Charles A. Sweet	George H Kent
Frederick L. Lovelace	W. Paxton Little

A. Monro Grier

* Deceased



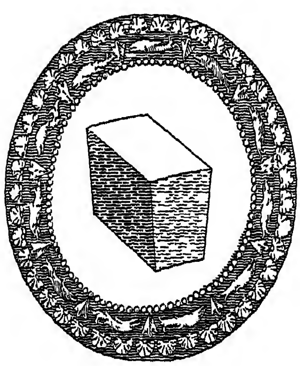
LA PARTIE CARRÉE

EDWARD DEAN ADAMS
President
THE CATARACT CONSTRUCTION COMPANY

Director
THE NIAGARA FALLS POWER COMPANY

FRANCIS LYNDE STETSON
Vice-president
THE CATARACT CONSTRUCTION COMPANY

Director
THE NIAGARA FALLS POWER COMPANY



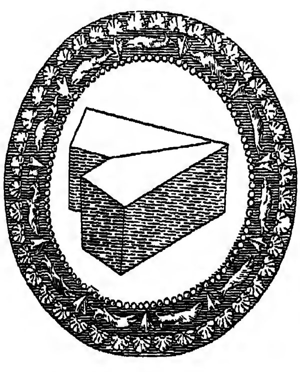
I

PIONEER OFFICERS AND DIRECTORS

LA PARTIE CARRÉE

EDWARD A WICKES
Vice-president
THE CATARACT CONSTRUCTION COMPANY
President
THE NIAGARA FALLS POWER COMPANY

WILLIAM BIRCH RANKINE
Secretary
THE CATARACT CONSTRUCTION COMPANY
Treasurer
THE NIAGARA FALLS POWER COMPANY

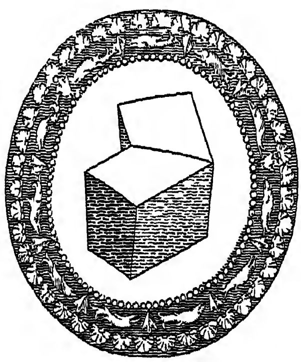


II

PIONEER OFFICERS AND DIRECTORS

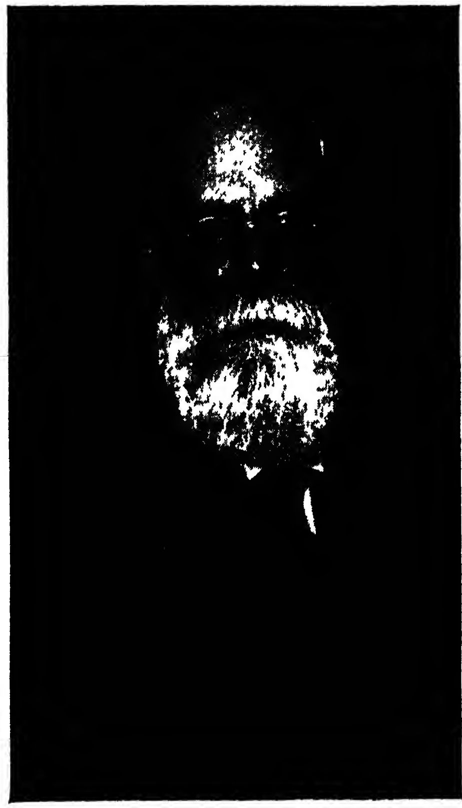
John Jacob Astor
Director
The Cataract Construction Company
Director
The Niagara Falls Power Company

George S. Bowdoin
Trustee
"Money Subscribers"
Director
The Niagara Falls Power Company



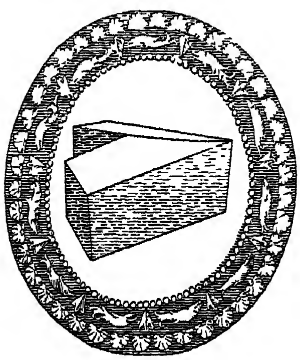
III

PIONEER DIRECTORS



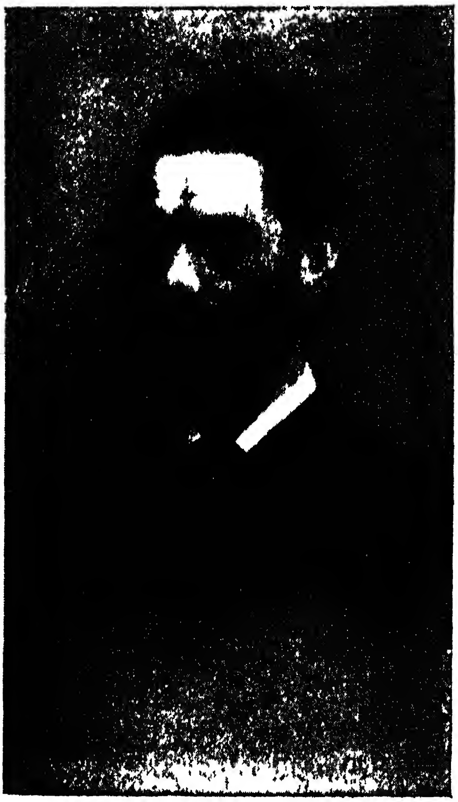
JOHN CROSBY BROWN
Trustee
"MONEY SUBSCRIBERS"
Director
THE CATARACT CONSTRUCTION COMPANY

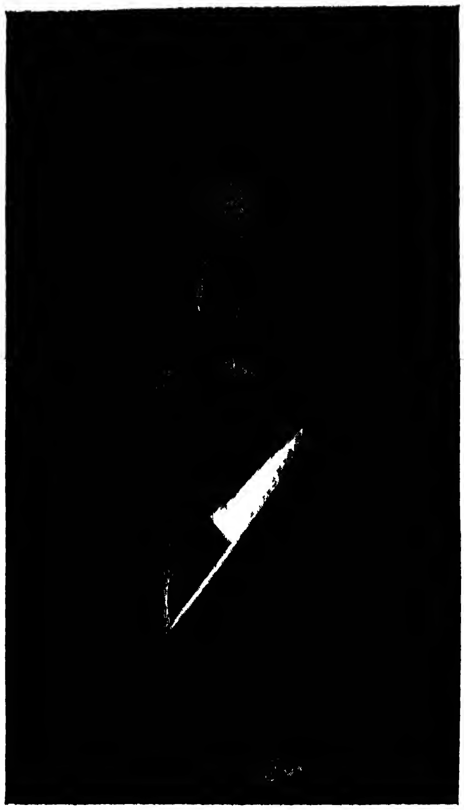
CHARLES F. CLARK
Director
THE CATARACT CONSTRUCTION COMPANY
Director
THE NIAGARA FALLS POWER COMPANY



IV

PIONEER DIRECTORS





Walter Howe
Director
The Cataract Construction Company

Charles Lanier
Trustee
"Money Subscribers"
Director
The Cataract Construction Company
Director
The Niagara Falls Power Company

V

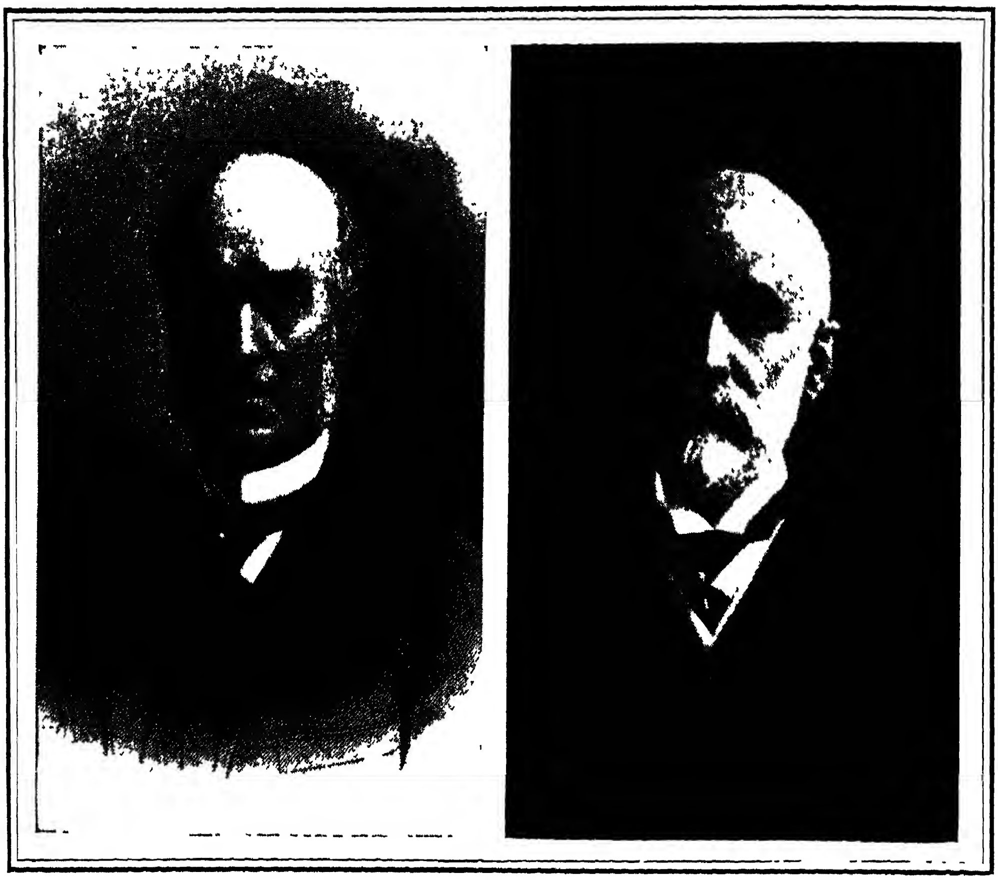
PIONEER DIRECTORS

Joseph H. Larocque
Director
The Cataract Construction Company
Director
The Niagara Falls Power Company

Leith of Fyvie
Director
The Cataract Construction Company

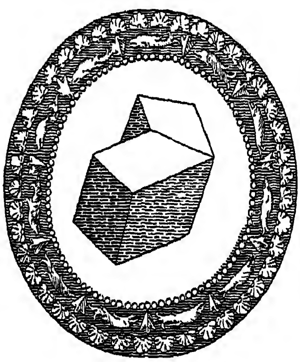
VI

PIONEER DIRECTORS



DARIUS OGDEN MILLS
Director
THE CATARACT CONSTRUCTION COMPANY
President
THE NIAGARA FALLS POWER COMPANY

FREDERICK W. WHITRIDGE
Director
THE CATARACT CONSTRUCTION COMPANY
Director
THE NIAGARA FALLS POWER COMPANY



VII

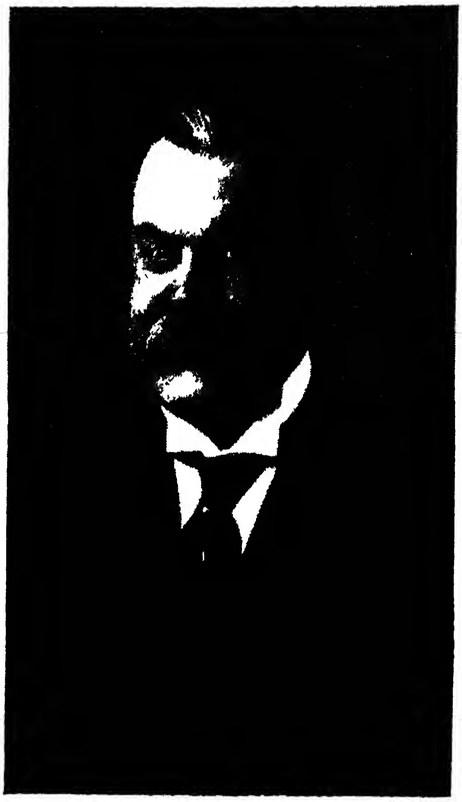
PIONEER DIRECTORS

NICHOLAS BIDDLE
Director
THE NIAGARA FALLS POWER COMPANY

LE GRAND S. DE GRAFF
Director
THE NIAGARA FALLS POWER COMPANY

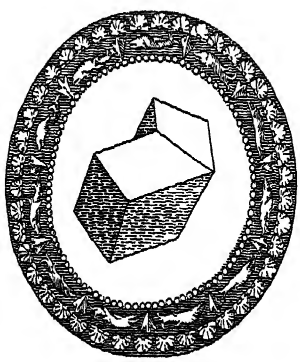
VIII

SUCCESSOR DIRECTORS



Temple Bowdoin
Director
The Niagara Falls Power Company

Arthur H. Masten
Director
The Niagara Falls Power Company



IX

SUCCESSOR DIRECTORS

Charles D. Dickie
Director
The Niagara Falls Power Company

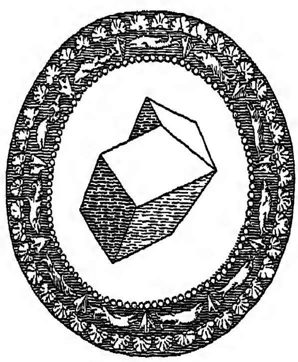
Ogden Mills
Director
The Niagara Falls Power Company

x

SUCCESSOR DIRECTORS

VICTOR MORAWETZ
Director
THE NIAGARA FALLS POWER COMPANY

ROBERT W. POMEROY
Director
THE NIAGARA FALLS POWER COMPANY

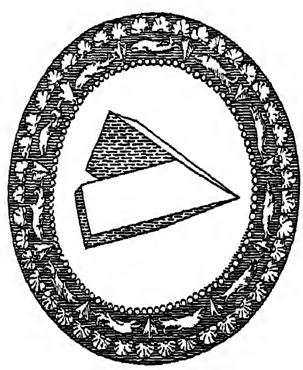


XI

SUCCESSOR DIRECTORS

De Lancey Rankine
Treasurer, 1891–1893
The Niagara Falls Power Company

Stacy C. Richmond
President, 1917–1918
The Niagara Falls Power Company

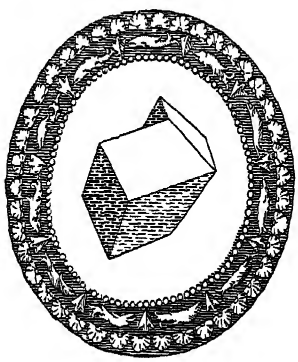


XII

SUCCESSOR DIRECTORS AND OFFICERS

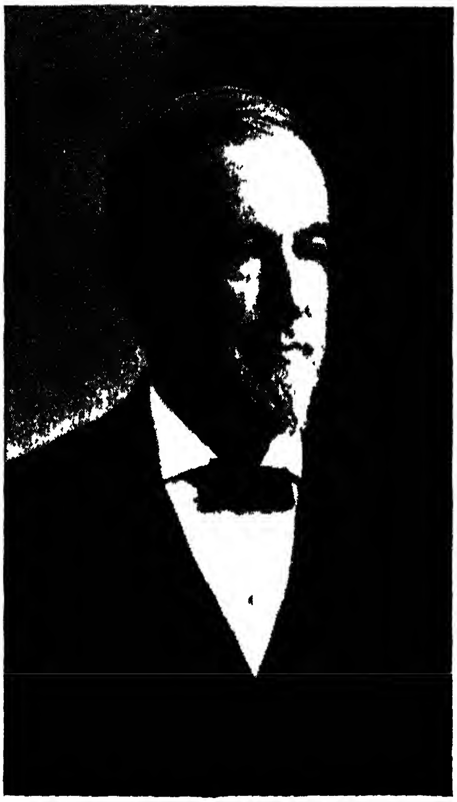
Carlton M. Smith
Director
The Niagara Falls Power Company

E. T. Stotesbury
Director
The Niagara Falls Power Company



XIII

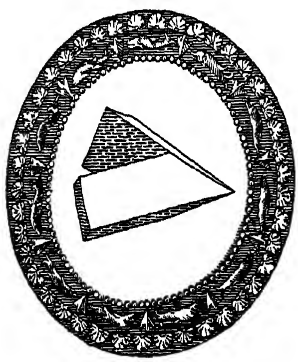
SUCCESSOR DIRECTORS



SUCCESSOR DIRECTOR AND OFFICER — PIONEER DIRECTOR AND OFFICER

CHARLES A SWEET
Vice-president
1894–1898
THE NIAGARA FALLS POWER COMPANY

GEORGE H. KENT
Director
THE CATARACT CONSTRUCTION COMPANY
Treasurer
THE CATARACT CONSTRUCTION COMPANY

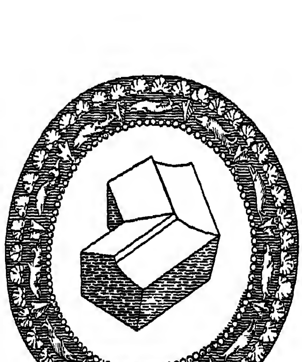


XIV

DIRECTORS AND OFFICERS

Frederick L. Lovelace
Secretary
The Niagara Falls Power Company

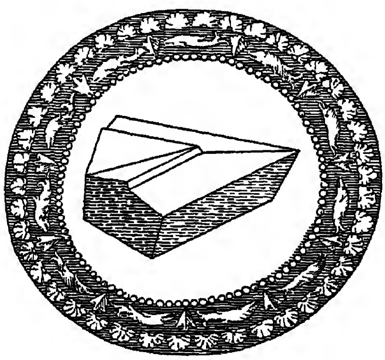
W. Paxton Little
Treasurer
The Niagara Falls Power Company



XV

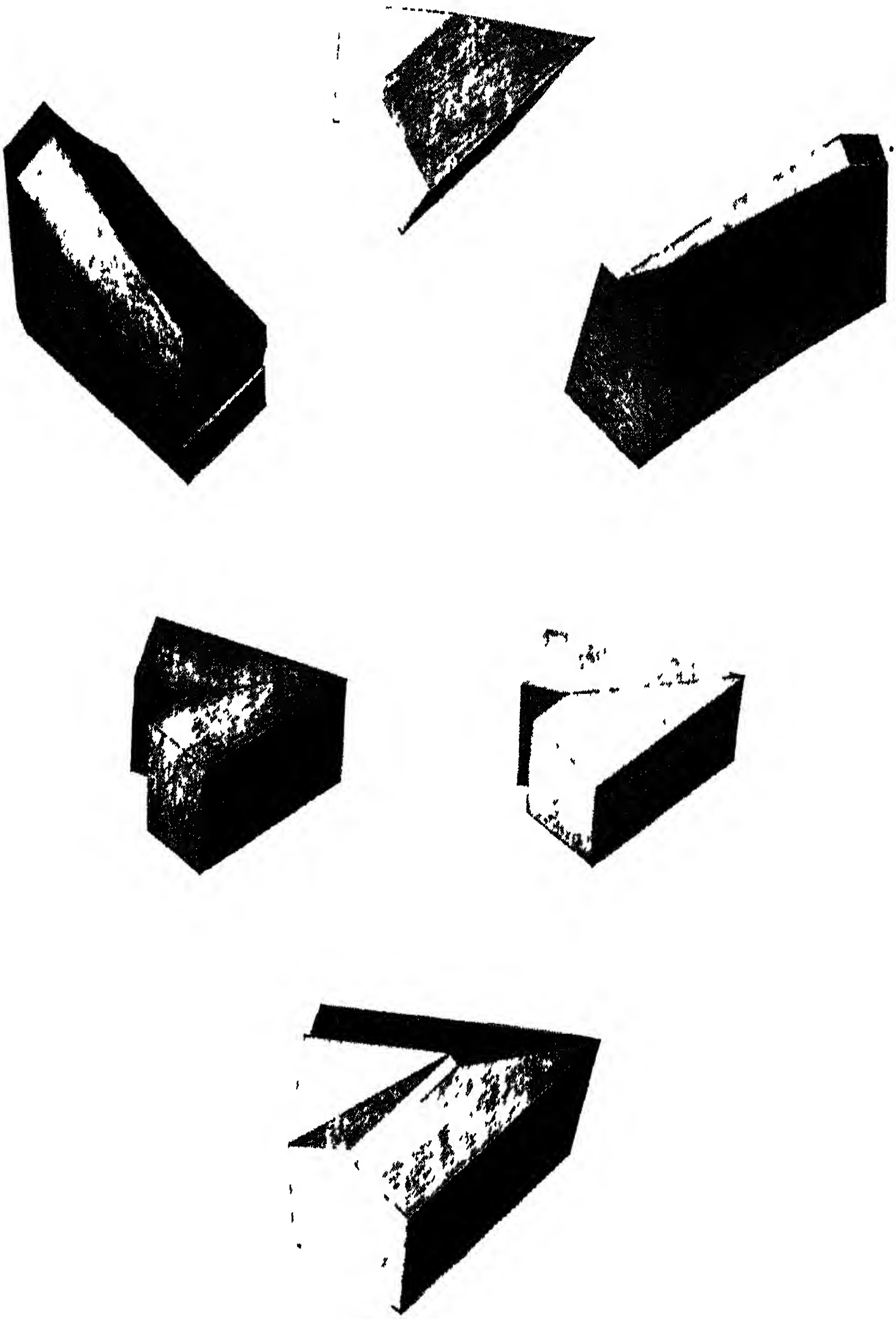
OFFICERS

A. MONRO GRIER
Director
THE CATARACT CONSTRUCTION COMPANY
President
CANADIAN NIAGARA POWER COMPANY



XVI

CANADIAN
PIONEER DIRECTOR AND PRESIDENT



THE GRANITE VOUSSOIR STONES FOR THE TUNNEL INTERSECTIONS INVOLVED PROBLEMS OF STEREOTOMY RARELY EQUALLED IN COMPLEXITY

ENGINEERING ORGANIZATION

THE CATARACT CONSTRUCTION COMPANY

1890-1900

THE NIAGARA FALLS POWER COMPANY

1900-1918

Chapter XIII

One of our pressing duties as engineers consists in devoting ourselves to the most serious consideration of applying all possible water-power to supplement the work of coal, and so reduce consumption or increase the utility of our most important asset.

SIR DUGAL CLERK, K.B.E., F.R.S.
CHAIRMAN OF CONJOINT BOARD
OF SCIENTIFIC SOCIETIES
REPORT ON WATER-POWER IN THE
BRITISH EMPIRE, 1922

ENGINEERING ORGANIZATION

CHAPTER XIII

THE PROBLEM

THE many questions, all of much importance, that surrounded the problem of harnessing Niagara, prompted the associates considering the enterprise, during the year 1889, to seek technical advice from engineers who had specialized in their professions and had already achieved success in their chosen fields.

It was recognized that the problem was novel in many ways. Many persons had boldly attacked it but all had failed; their experiences were interpreted by their successors as indicating what should be avoided rather than as showing the way for further efforts to solve the problem.

Some of the impressive facts to be kept constantly in mind were:

Water similar in quantity and velocity had not yet been controlled for power use.

The New York State Reservation on the river bank restricted approach for about 1½ miles, both above and below the Great Falls.

The change of the river's course at the falls created a right angle in the bordering lands that attracted settlers, this property being considered desirable for residence as well as for manufacturing, because of its nearness to the water and its height above the river for power development.

The top-soil to an average depth of about ten feet, covered horizontal layers of hard limestone and of shale, that required blasting for excavations.

ENGINEERING PROGRESS

Progress may be recapitulated in the following brief paragraphs:

The preliminary investigations[1] in 1889, by conference with experts were in the nature of friendly counsel and opened the vista of doubt and difficulties.

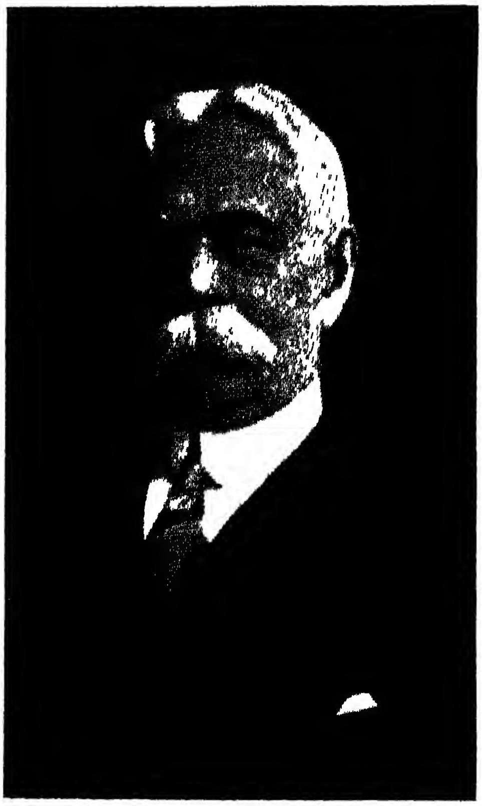
Thomas A. Edison, Dr. Henry Morton, of Hoboken, and Dr. Coleman Sellers, of Philadelphia, were among the first professional engineers and scientists retained to examine the documents submitted and to advise as to the wisest course for an exhaustive study of the enterprise.

Clemens Herschel, of Holyoke, hydraulic engineer, was also called in to assist in the analysis of the claims made for the project under examination.

As soon as it became apparent that electricity in its latest developments had taken its place for consideration by the side of pneumatic and hydraulic transmission of power, Prof. Henry A. Rowland of Baltimore, physicist, was retained as adviser.

[1] Reported at length in Chapter VIII.

Dr. Coleman Sellers, who had assisted in investigating the subject in the latter part of 1889, was appointed consulting engineer of The Cataract Construction Company (subsequently chief engineer) and chief engineer of The Niagara Falls Power Company, from January 1, 1890, and immediately devoted himself to a thorough understanding of the local situation at Niagara,



John Bogart
Consulting Engineer
1890–1893

the past attempts to utilize the waters of the river and the project of Thomas Evershed for water-power development that had been acquired by the Niagara River Hydraulic Tunnel, Power and Sewer Company which was then under investigation by a financial group in New York.

John Bogart, of Albany, New York, state engineer, then engaged in measuring the recession of the Great Falls, was retained as consulting engineer to prepare a detailed and large-sized map of the location under consideration, showing the contour lines on land and under water, to facilitate the

preparation of plans for construction, the probable costs of which were uncertain and of great interest at that time from a financial point of view.

In this work he was assisted by Albert H. Porter, a civil engineer, recently of the engineering staff of the New Croton Aqueduct of New York, who was appointed resident engineer at Niagara Falls.

ALBERT H. PORTER
RESIDENT ENGINEER
THE CATARACT CONSTRUCTION COMPANY

Mr. Bogart and Mr. Porter assisted Dr. Coleman Sellers, chief engineer, in his organization of the engineering staff of the company; Clemens Herschel, the hydraulic engineer, also co-operating in this work.

While each of these engineers presented one or more written reports, they all attended personal conferences that greatly enlightened the investigations and facilitated the formulation of constructive plans for the year 1890.

As soon as it was determined to proceed with the Niagara project, to the extent, at least, of constructing the first section of the tunnel, a 20,000

horse-power development for distribution, a group of engineers were selected that were competent to advise the directors of The Cataract Construction Company, under the leadership of Dr. Coleman Sellers.

NIAGARA ADVISORY BOARD OF ENGINEERS

This organization was made by Dr. Coleman Sellers, as chief engineer, for the purposes of considering formally, at recorded meetings and otherwise, the various questions that came before its members for determination as the policies of The Cataract Construction Company were developed by the International Niagara Commission and other scientific advisers and were submitted to the advisory board of engineers for consideration in application to the local conditions and prospective requirements.

The advisory board of engineers was organized from among those enlisted in the services of the two companies, consisting of

- Dr. Coleman Sellers, Chairman, Chief Engineer of The Niagara Falls Power Company
- John Bogart, Secretary, Consulting Engineer of The Cataract Construction Company
- George B. Burbank, Chief Engineer of Construction, of The Cataract Construction Company
- Clemens Herschel, Hydraulic Engineer, of The Cataract Construction Company
- Albert H. Porter, Resident Engineer, of The Cataract Construction Company
- Theodore Turrettini, Foreign Consulting Engineer, of Geneva, Switzerland, joined in 1891.

Dr. Sellers represented the cataract company and its allied interests upon the International Niagara Commission, a full account of which is given in Chapter X; and Colonel Turrettini represented thereon the engineering organizations of Switzerland and became the foreign representative of the cataract company after the disbandment of the commission.

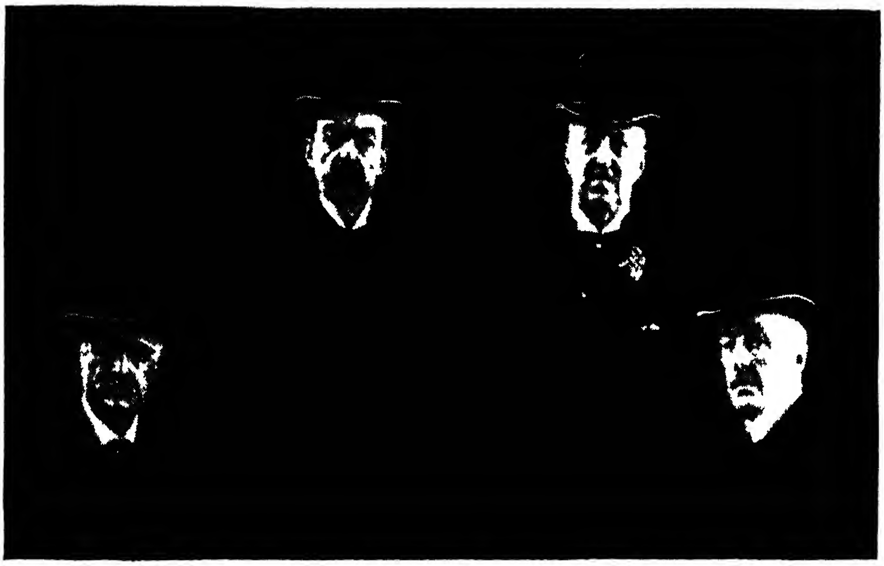
The advisory board of engineers held its first meeting February 27, 1890, and continued its deliberations until December 31, 1892, when it disbanded.

There were many meetings, held mostly at the office of The Cataract Construction Company at Niagara Falls, but occasionally at New York in conference with the directors of the company.

The records of the meetings show that they were frequently attended by the various consulting engineers engaged in special services for the company.

OFFICIAL CONFERENCES AT NIAGARA

The officers of the company were frequent visitors at Niagara and often at the conferences of the advisory board of engineers. They were occasionally accompanied by technical experts, particularly during the period of the World's Fair in Chicago in 1893, when the visiting foreign engineers were numerous and manifested so much interest that it was thought that they came to this country principally to examine the Niagara construction, and incidentally to take a "look in" at the Chicago fair.



La Partie Carrée

Edward D Adams, *President* — Francis Lynde Stetson, *Vice-president*

Edward A Wickes, *Vice-president* — *The Cataract Construction Company* — William B Rankine, *Treasurer*

The officers of the construction company generally appeared in Niagara Falls on Saturday mornings and devoted their time, at the works, to the construction, its progress and problems, and in the office to the examination of plans and estimates, and to conferences, returning to New York by the Sunday night train, usually after dining with associates in Buffalo.

LA PARTIE CARRÉE

They were Edward D. Adams, president, Francis Lynde Stetson, vice-president, Edward A. Wickes, vice-president, and William B. Rankine, treasurer, who were known among their associates as La Partie Carrée, and in

effect were a sub-committee of the executive committee and prepared the principal business matters for its consideration, by their personal inspections of the construction and their conferences with the engineers at Niagara.

In 1897, when the construction works had proceeded sufficiently to be visualized as a complete project and would-be users of the developing system of power distribution began to comprehend its facilities and to negotiate for locations and use in manufacturing, Mr. Rankine established his residence as the chief executive of the company at Niagara Falls. It was there that he died in 1905, having seen the fruition of his labors and enjoyed the friendship of his associates. The other members of this Partie Carrée survived the thirty-year period of their Niagara venture, and assisted at the concluding session of the directors of The Niagara Falls Power Company, when they surrendered their control of a successful enterprise and authorized its union with its successful and older neighbor, the Hydraulic Power Company of Niagara Falls.

ENGINEERING CONSIDERATIONS

The advisory board of engineers, during the two years of its existence, had under consideration some of the most interesting scientific problems in engineering to solve, practically, in their application to the conditions obtaining at Niagara Falls, where water in quantity and force, without precedent in control, was to be harnessed by methods to be selected from several previously employed in a comparatively unimportant manner and under entirely different conditions.

The advisory board of engineers brought to their work an unusually broad basis of scientific attainments and extended personal experience to guide them in their deliberations.

The Cataract Construction Company had consulted some of the leading engineers in this country, upon the question, "How can we utilize commercially the waters of the Niagara River?" They all recognized in some degree that old methods might be improved by new sciences, but so little was known of the art of their application, especially under such unprecedented conditions as those at Niagara, that, although their reports made mention of such theories, they pointed out the speculative risks involved in what would necessarily prove very expensive experiments, and advised dependence at first only upon that which had been tried and continued for many years of successful use.

The private reports from scientific circles abroad, of important progress in the investigation of electrical methods for the utilization of water-powers, prompted a careful research upon the subject, which resulted in the reference of the Niagara problem to a group of international scientists, whose decisions

would be recognized as of the highest authority, and whose opinions and their supporting details of definite statements and proposals furnished a broad platform upon which the advisory board of engineers could build a new structure, that would be adapted to the locality of the Great Falls, and would really represent the state of the hydraulic and associated arts at the date of its construction.

PROBLEMS AWAITING SOLUTION

The following brief statement summarizes the principal subjects that the advisory board of engineers was called upon from time to time to consider, in 1890 and 1891:

The Main Tunnel, or Tail-race,
- its first section, with a capacity of 120,000 horse-power,
- the shortest line from water-inlet to outlet,
- its grade, considering the stratification of the rocks and the river level,
- cross-section and shafts,
- lining or surface-finish,
- portal and ice protection;

The Second, or Relief Tunnel,
- its location and possible details of construction,
- connection with main tunnel,
- shafts and portal;

The Inlet-canal, or Head-race,
- location,
- capacity for 200,000 horse-power,
- provision for 100,000 electric horse-power and 100,000 pneumatic horse-power, to be developed in separate power-houses on opposite sides of the canal,
- ice protection and discharge;

The Wheel-pit Slot,
- to provide for at least 20 water turbines each of not less than 5000 horse-power, to be directly connected by a single shaft to its corresponding engine of power conversion;

The Supplemental Cross-tunnel,
- a connection for power development at foot of canal and on land east of canal;

The Manufacturing Districts,
their locations,
mill-sites,
streets and power conduits,
railway sidings,
trolley connections;

The Residential District,
its location,
improvement by plan of gradual development with dwellings,
streets and sidewalks,
sewage conduits and disposal works,
potable water and distribution under pressure,
drainage system,
electric lighting,
store,
post-office,
hall for meetings,
house for school,
fire protection;

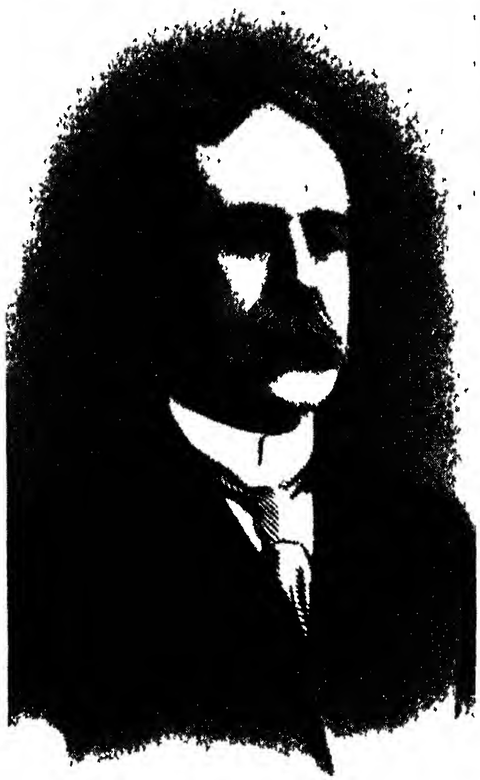
The Terminal, or Junction, Railway,
its location,
crossings of railways and streets,
connections with other railways,
equipment and operation,
yards for storage and transfers,
sidings at factories,
tariff relations with connecting railroads and local customers;

The Water Company,
for supply of potable water,
pumping and filtration plant,
fire protection for new community;

The Central Power Stations,
and office building.

The awarding of the contract for the alternators following the determination of the vital questions involved in the hydraulic and electric systems

adopted, and the near approach of completion of much of the construction work in progress, permitted the disbandment of the board of engineers of The Cataract Construction Company on January 1, 1894, and the retirement, on April 1, 1894, of George B. Burbank as its chief engineer, in charge of



GEORGE B. BURBANK
RESIDENT CONSULTING ENGINEER
1891-1893
CHIEF ENGINEER
1893-1894

construction. The following resolution to his credit was placed in the records of the company:

RESOLVED, That this company hereby make record of its appreciation of the faithful service, ability and integrity which have characterized Mr. Burbank's connection with its Engineering Department since June, 1891, as Resident Consulting Engineer and as Chief Engineer.

DETERMINATION OF HYDRAULIC SYSTEM

The most important subject for determination by the advisory board of engineers was that of the hydraulic system to be adopted in lieu of that proposed under the Evershed plan. The greatest influence in this decision, other than that of financial expenditures required, was the preliminary adoption of the idea of a central station and a single water-inlet and a single discharge for the entire hydraulic development.

As this question pertained principally to the engineering domain of Clemens Herschel, the hydraulic engineer, educated in Germany, familiar also with the language and works of French engineers, and of extended experience in this country in various forms of applied hydraulics, it was thought advantageous to him, as well as to the cataract company, if he should be brought into direct personal relations with the eminent engineers constituting the International Niagara Commission in London.

Mr. Herschel, therefore, conferred with the commission in London about the first of October, 1890, where he availed of his opportunity for an exchange of experiences, particularly with Messrs. Unwin, of London, Turrettini, of Geneva, and Dr. Sellers, the company's chief engineer, who had been in Europe as a member of the commission since its organization in June, 1890. Mr. Herschel returned in the following October to Niagara, where he put into effect a change in the proposed grade of the tunnel, recommended some other changes in the Evershed plan, and developed his own plans for the portal, ice-run, and other details of the tunnel, that were adopted.

Many minor questions, incidental to the foundation of a system of power distribution from a central station to a large and extended area, were considered by the advisory board of engineers, before the end of the year 1893, that was a period of great activity.

INTERNATIONAL NIAGARA COMMISSION

The final series of sessions of the Niagara commission were held in London commencing January 29, 1891, and continuing for six days, for the consideration of the projects submitted in competition. Messrs. Herschel and Porter, of the advisory board of engineers, attended those sessions by invitation and heard the explanations given by the competitors of the details of their projects. There were fourteen separate proposals, several of which included two or more designs. Four proposals were for developing power, two for distribution, and eight for both development and distribution. Complete plans, in English measure, and estimates of costs, with elaborate descriptive memoirs in English, were furnished each of the five members of the

commission for consideration in advance of the meetings at which the competitors were present with their technical experts.

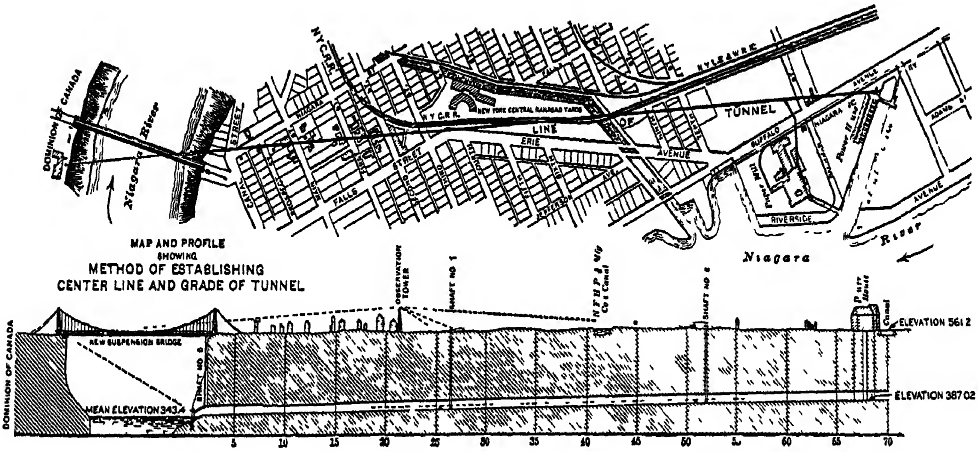
Two of the foreign competitors availed themselves of the general invitation to visit Niagara for conferences with the company's engineers prior to the completion of their design and memoirs.

The visiting engineers from Europe and New York were in daily conference between the sessions of the commission in London.

Messrs. Herschel and Porter returned home in the latter part of February, and Dr. Sellers in March, 1891, rendering their several reports of the conferences attended, visits made to engineering works, and impressions received.

THE CONSTRUCTION PERIOD

As the construction work progressed, additional engineers were engaged to advise and to design the machines for development and distribution of



electric power, and to formulate working plans, prepare specifications, secure responsible and skillful contractors, supervise their work, and generally to contribute their experience and ability for the guidance of the officers in formulating the policies of their company.

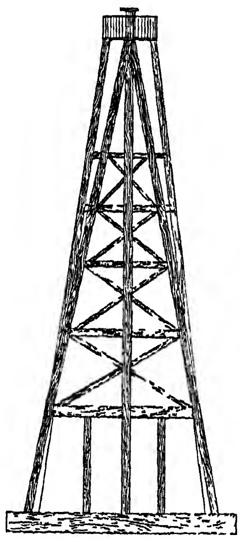
Although the scientific group selected to advise and direct the operations of the company was mainly composed of technical experts, specialists in the various departments of science embraced in the problem undertaken, there were engineers in the group who were prepared for emergencies, even where action involved the use of knowledge pertaining to other departments of science than their own specialty.

This resourcefulness in time of need, this adaptability to the unexpected, is one of the valuable attributes of the American engineer, particularly when in the field, as was frequently manifested in the design and execution of the novel undertaking at Niagara.

A young engineer, assisting in the surveys preceding the construction of the tunnel, describes an incident in his experience that illustrates the use of some knowledge of entomology and botany to overcome an obstacle that seemed insuperable, temporarily at least, when time and accuracy were of great importance in his surveying program.

The tunnel was projected to pass under the most inhabited portion of the town of Niagara, on the shortest line to the lower river; alignment towers were erected at various points, from which the surveyors were able, in the autumn of 1890, when the foliage had fallen, to sight their lines over the intervening buildings and trees.

When revising the proposed tunnel line in the following spring, after the new leaves had appeared on certain of the larger trees, it was found that



A Sketch of the Alignment Tower Erected Near the New York Central Railroad Station at Niagara Falls, Comprising Two Towers, One within the Other, but each Supported Independently

the former line of sight was not clear, and trouble and greater chance of error were anticipated if it became necessary to carry the line forward by offsets. The engineer explains his problem and its solution as follows:

In determining the line of the tunnel from the portal it was necessary to throw the line to the Canadian side of the gorge. The first obstacle in the way was the New York Central Railroad station. This, of course, could not be cut through. An observation tower was built alongside of the station building, in order to get over, not only that building, but the town of Niagara and the houses that lay between that point and the American side of the gorge. From the top of this tower it was a simple thing to throw the line into Canada after points were established on the Canadian side of the gorge; the difficulty lay in the fact that such points in Canada, as could be observed from the

tower, were too far back from the edge of the gorge to throw the line down to the portal of the tunnel, which was not far above the water level on the American side. The sole obstacle to the necessary observation of points close to the edge of the Canadian side of the gorge was a basswood tree on the American side, situated in the street just the other side of the station building.

The owners of the tree were approached in an effort to obtain permission to remove a few small top branches, for which they would be fairly compensated. An offer was even made to purchase the tree, but the owners, possibly taking advantage of our predicament, held out for an exorbitant price.

Feeling that it would be an unwarranted waste of time to wait until the tree should shed its leaves in the fall, I racked my brains for an alternative solution. It occurred to me that some insect pest might be found, which would hasten the effect of the autumn weather. As I was driving about the country a good deal in those days, on both the American and the Canadian sides, in an effort to locate a sand or gravel deposit, I was afforded abundant opportunity for observation of the ravages of insects upon the various species of trees of the neighborhood. It was, however, only after long search that I came, one day on the Canadian side, upon a clump of similar trees infested with caterpillars. As they were of easy access, I cut two or three small branches on which the nests were built, and brought them back to the office of the company on the American side.

Then came the question of installing these new tenants in the peace haven. I was satisfied that it was not a daylight operation, and hesitated about taking any one into my confidence. Prompt action was necessary, as there were not leaves enough on the branches that I had brought home to feed the caterpillars for any length of time. The tree was a hard one to climb, so I tied a stone to the end of a fishing line and threw it into the tree, and after two or three trials I was satisfied with the crotch of the limb that the stone went over. By this means I hoisted my caterpillar nests into the tree. The crotch being a sharp one, they jammed very securely, and I felt safe in breaking the string. The caterpillars, known as clisiocampa disstria, or "forest tent caterpillar," did their work with surprising rapidity, and no further negotiations were necessary with the owner of the tree. Within ten days we were able to get a glimpse of the edge of the gorge on the Canadian side and to set a point on the main line without going to the trouble of offsets, so that our line went through promptly by direct sighting.

In addition to the members of the advisory board of engineers of The Cataract Construction Company, organized in 1890 by Dr. Coleman Sellers, chief engineer, there were appointed, from time to time and for periods as required in the progressive development of this company's affairs:

CONSULTING ENGINEERS

William Cawthorne Unwin, London, late member and secretary International Niagara Commission

Col. Theodore Turrettini, Geneva, late member International Niagara Commission

Prof. George Forbes, London, Electrical Engineer

Arthur E. Kennelly (Kennelly and Houston), Philadelphia, Electrical Engineer

Gen. Daniel W. Flagler, U. S. A., Buffalo, New York

Charles C. Egbert, Niagara Falls, New York, Mechanical Engineer

WILLIAM A. BRACKENRIDGE
CHIEF ENGINEER OF
THE CATARACT CONSTRUCTION COMPANY

Horatio A. Foster, New York, Expert Mechanical and Steam Engineer

Prof. James Furman Kemp, New York, Geologist

Col. Walter Katté, New York, Civil Engineer

As the preparations for construction proceeded, additional engineers were engaged, and later, from time to time, others joined the staff for the

installation of the turbines and shafts, for the erection of the generators and switchboard, and for the operation and maintenance of the hydro-electric machinery:

CONSTRUCTION ENGINEERS

William A. Brackenridge, Resident Engineer and Chief Engineer of The Cataract Construction Company

George Frederick Simpson, Assistant Engineer, expert in stereotomy, in charge of certain details of tunnel design and construction

A. H. Van Cleve, Resident Engineer and later Consulting Engineer

Mac Donough Craven, Division Engineer

William S. Humbert, Division Engineer

Edward D. Very, Division Engineer

Edward D. Bolton, Division Engineer

Francis N. Biron, Division Engineer

C. F. Lawton, Acting Assistant Engineer

Albert W. Pierson, Construction Engineer

OPERATING ENGINEERS

Philip P. Barton, General Manager

Lorin E. Imlay, Superintendent

The foreign designers of the hydraulic machinery sent their representatives to this country to supervise the construction, erection and operation of their devices, some of which were made in Switzerland and some in Pennsylvania.

The first three turbines were made by the I. P. Morris Company, of Philadelphia, under the supervision of Messrs. Rudolphe Baumann and H. Vogel, mechanical engineers from Geneva, representing Messrs. Faesch and Piccard, designers of the Niagara turbines of the first power-house, to whom the highest award was made by the International Niagara Commission for hydraulic projects.

To prepare for the erection and operation of the turbines, De Courcy May, general manager of the I. P. Morris Company that constructed them, joined the engineering staff of The Cataract Construction Company at Niagara, as its engineer and general superintendent of the machinery of the power-house.

Soon after the installation in 1897 of the last of the first group of four electrical alternators in Power-house Number One, Lewis B. Stillwell,[1] chief

[1] For portrait, see Chapter XXII, Volume II.

electrical engineer of the Westinghouse Electric and Manufacturing Company, was appointed electrical director of The Cataract Construction Company. Mr. Stillwell had taken an important part in the design and supervision of construction of the Westinghouse apparatus. Philip P. Barton,

PHILIP P. BARTON
THE NIAGARA FALLS POWER COMPANY
AND ITS FILIAL COMPANIES
1898–1919
VICE-PRESIDENT AND MANAGER
1910–1919

who became assistant electrical superintendent of The Niagara Falls Power Company, had also served in the works of the Westinghouse Company.

The General Electric Company designed and built all the electrical alternators and their auxiliary apparatus for Power-house Number Two.

In the organization of a staff of young electrical engineers to take charge of the first switchboard, in Power-house Number One, three applicants were selected who served in three shifts of eight hours each, and remained in their

position for several years. They were those here named with their present engineering positions:

J. B. Whitehead, Professor of Electrical Engineering and Dean of School of Engineering, Johns Hopkins University, Baltimore, Maryland

LORIN E. IMLAY
THE NIAGARA FALLS POWER COMPANY
AND
CANADIAN NIAGARA POWER COMPANY
SUPERINTENDENT OF OPERATION
1905-1919

Raymond S. Masson, Consulting Engineer, Los Angeles, California

Simon Brewster Storer, President and Chief Engineer, Seneca River Power Company, Syracuse, New York

Harold W. Buck,[1] of the engineering staff of the General Electric Company, became the electrical engineer in charge of Power-house Number Two

[1] For portrait, see Chapter XXVIII, Volume II.

and of the initial half of the Canadian Niagara Power Company development as well as all other portions of the electrical system, and a valued addition to the electrical engineering forces of the cataract company. In this, as in the instances previously mentioned, successful design, construction, installa-

ALEXANDER D. ROBB
VICE-PRESIDENT
THE NIAGARA FALLS POWER COMPANY, MCMXVIII
FIRST EMPLOYED BY DR COLEMAN SELLERS AS MECHANICAL INSPECTOR, 1904; ASSISTANT SUPERINTENDENT CANADIAN NIAGARA POWER COMPANY, 1906, SUPERINTENDENT, 1918, SUPERINTENDENT CANADIAN NIAGARA POWER COMPANY AND NIAGARA PLANT OF THE NIAGARA FALLS POWER COMPANY, MCMXVIII, 1919

tion and operation were acceptable recommendations for the service of an engineer to care for the product of his skill.

The distant transmission line to Buffalo was also the subject of serious study, as one of many novel devices, without precedent, requiring an engineering and inventing vision to anticipate and prevent the possibility of accident or mistake. The construction of this line was placed under the

charge of Paul M. Lincoln,[1] now Professor-Director in charge of the Department of Electric Engineering at Cornell University.

All the appointments mentioned were justified by their results. The practical experience in design and construction, the careful supervision of operation

CHARLES C EGBERT
MECHANICAL ENGINEER
CORNELL UNIVERSITY, 1895
SWISS FEDERAL POLYTECHNICUM, 1896
THE NIAGARA FALLS POWER COMPANY AND
CANADIAN NIAGARA POWER COMPANY
1901–1918

and repair, with the spirit of personal interest in comparative performance, made the opportunities of these appointments a matter of satisfaction to the officers of the company. The later recognition of these men by their professional associates is shown by their records after the three power-houses had been completed, their hydro-electric prime movers installed, and their capacity output successfully distributed to local and distant consumers.

[1] For portrait, see Chapter XXVIII, Volume II.

The American Institute of Electrical Engineers elected to the honorable position of president, each in his turn, the three former electrical engineers of The Niagara Falls Power Company, Lewis Buckley Stillwell (1909–1910), Paul M. Lincoln (1914–1915), and Harold W. Buck (1916–1917). A. E. Kennelly (1898–1900), past-president of the American Institute of Electrical Engineers, was also employed by the cataract company as consulting engineer. The careers of these engineers and contributions by them to this history appear elsewhere.

The engineering organization of The Niagara Falls Power Company at the date of its consolidation with its successor company of MCMXVIII was as follows:

Philip P. Barton, Vice-president and General Manager

Charles C. Egbert, Mechanical Engineer

Lorin E. Imlay, Engineer-Superintendent

Alexander D. Robb, Engineer

The engineering department of the new consolidated organization was that already under the leadership of John L. Harper, as chief engineer.

FINANCES

1890-1918

THE CATARACT CONSTRUCTION COMPANY

1890-1900

THE NIAGARA FALLS POWER COMPANY

1900-1918

1924

BUFFALO, NIAGARA AND EASTERN POWER CORPORATION

1925

CHAPTER XIV

CASH

Provided as Treasury Assets by

The Cataract Construction Company, 1890–1900 . . .	$ 7,044,500
The Niagara Falls Power Company, 1900–1918 . . .	13,226,320
Total Cash, 1890–1918	$20,270,820

FINANCES

OF

THE CATARACT CONSTRUCTION COMPANY

AND

THE NIAGARA FALLS POWER COMPANY

CHAPTER XIV

FINANCIAL BASIS OF THE CATARACT CONSTRUCTION COMPANY IN ITS SYNDICATE SUBSCRIPTION OF JANUARY 17, 1890

AFTER careful consideration, during 1889 and the beginning of 1890, of the several reports upon the Niagara project by various expert engineers and numerous conferences with each, and extended investigations as to the commercial as well as the various financial questions involved in the undertaking, it was the opinion of those who had expressed an interest in the proposed venture, that:

1. The primary expenditure should be limited to the probable cost, liberally estimated, of the shortest section of tunnel and its appurtenances that would produce manufacturing facilities sufficient to provide interest upon the capital expenditures and the expense of maintaining the power-plant;

2. Additional acreage should be acquired, while obtainable at moderate prices, to provide greater areas for factory requirements, shipping, dwellings, and local transportation;

3. Improvements of water-supply for potable purposes, and extension of the sewerage and lighting systems, should be provided;

4. The construction of the first section of the tunnel and the inlet-canal for the water-supply should be contracted for as soon as the necessary rights-of-way and property could be secured and plans prepared.

It was recognized that the method of developing the power and its distribution, locally as well as at a distance, was an open question, and that while the tunnel was under construction there would be ample time to investigate the various systems in use, particularly the latest designs adopted abroad, before deciding whether compressed air, electricity, or other means should be utilized in distributing the power.

The power and construction organizations provided had been given general powers of capitalization that were considered sufficiently comprehensive and flexible to provide suitable securities for the financing of the undertaking.

FINANCIAL ORGANIZATIONS

The Niagara Falls Power Company, the permanent organization, had been granted under special and amendatory laws of the State of New York a liberal charter under which it was authorized to issue its capital stock and bonds, practically to whatever extent required, for its needs in construction and finance.

The Cataract Construction Company was the organization designed to represent all the money subscribers to the enterprise and to be the means of their profiting by its contract with The Niagara Falls Power Company for the design and construction of the entire property to be acquired by the latter, by the issue of its shares and bonds to The Cataract Construction Company in payment therefor.

The Cataract Construction Company was organized June 13, 1889, with an authorized capital stock of $25,000 divided into 500 shares of a par value of $50 each. It was authorized to commence business upon a paid-up capital of $5000, which was subscribed and paid in cash by Edward A. Wickes, fifty shares, Francis Lynde Stetson, forty shares, and William B. Rankine, ten shares, all of New York City.

It also entered into an agreement on July 5, 1889, with all the stockholders of the Niagara River Hydraulic Tunnel, Power and Sewer Company[1] whereby they agreed to sell their shares to The Cataract Construction Company for $200,000, payable, one half in money and one half in bonds, under various conditions as in said agreement set forth. In this arrangement the cataract company acquired all the lands and options on lands, rights-of-way and franchises of the Niagara company, and became its business and financial agent.

An increase of the capital stock of The Cataract Construction Company to $25,000, the maximum authorized under its charter, was voted by the stockholders January 25, 1890, and the officers were authorized to receive subscriptions in cash for such increase of 400 shares, at their par value of $50 each.

SYNDICATE SUBSCRIPTION

An agreement under date of January 17, 1890, was made by the cataract company with subscribers to its shares and to the first mortgage bonds of

[1] Name changed Nov. 11, 1889, to The Niagara Falls Power Company.

the Niagara company. All subscriptions were made for single blocks, or multiples, of the aforementioned securities:

The Cataract Construction Company, one share at par value . . .	$ 50
The Niagara Falls Power Company, $7250 first mortgage five per cent bonds, at 90 per cent	6,525
Total cash for each "block" of securities	$6,575

As there were 400 shares of cataract company thus subscribed at par of $50, amounting to	$ 20,000
there were, in proportion (1.400) to this original subscription, $2,900,000 Niagara bonds at 90 per cent, amounting to	2,610,000
Total cash subscription	$2,630,000

The bond subscriptions were payable when and as called for by The Cataract Construction Company, provided that (a) no call should be for more than 10 per cent; (b) at least one month should elapse between the first call and the second call; (c) at least eight months should elapse between the second call and the last call. Cataract stockholders had the privilege of subscribing for additional bonds at 90 per cent, whenever further sales were to be made by the cataract company.

As the cataract company became entitled to receive bonds under its construction contract with the Niagara company, they were delivered to the bankers, George S. Bowdoin, of J. P. Morgan & Company; John Crosby Brown, of Brown Brothers & Company, and Charles Lanier, of Winslow, Lanier & Company, as a committee of subscribers who were empowered to hold, manage and sell the bonds for account of the subscribers.

Scrip for bonds instead of cash might, at the option of the cataract company be paid for interest accruing during construction upon any and all payments upon subscriptions.

This plan of finance was so framed as to give every stockholder in the cataract company his proportionate share of all construction profits, and to the "money subscribers" such additional advantages as might accrue under the preferential right to subscribe for bonds at 90 per cent.

The financial basis of syndicate subscription of January 17, 1890, for the inauguration of the Niagara water-power enterprise, was submitted to a meeting of subscribers, fully discussed, explained in detail by engineers present, and approved as the basis of the agreement of the above date for subscriptions of a total sum of $2,630,000 cash.

It was estimated that this total fund of $2,630,000 cash and $393,000 in bonds to be used in acquiring land, would secure for the enterprise the following described property and privileges:

1. The franchise and entire capital stock of the Niagara company;
2. The right-of-way for the tunnel, about 1 mile, under municipal, corporate and individual grants;
3. The main tunnel shafts, inlet-canal, ten wheel-pits, wheels and their cables for driving machines at the surface;
4. 250 acres of valuable land, controlling 2 miles of the water-front, and appurtenant riparian rights, lying above the park reservation and between Niagara River and the New York Central Railroad, including 75 acres under water;
5. About 1000 acres of other land suitable for building;
6. The water-works supplying the village of Niagara Falls.

These comprised a complete plant to produce hydraulically 20,000 horse-power. A product of 20,000 mechanical horse-power delivered, continuously, on the floor of the power-house, to a customer at $10 per horse-power per annum for twenty-four hours, would yield $200,000, which would provide five per cent interest per annum on $3,000,000 bonds, and leave $50,000 for use in paying an installment of sinking-fund on the bonds and current expenses in operation of the plant.

MONEY SUBSCRIBERS

When the agreement of January 17, 1890, between The Cataract Construction Company and the "money subscribers" was submitted to Darius O. Mills for his signature, he asked that he might sign for twice the amount he had requested, remarking that if he had been a younger man, he would have liked to take the entire amount for his own account.

The following list comprises the names of the stockholders of the cataract company and of the subscribers to its first construction fund:

DOMESTIC ASSOCIATES

Edward D. Adams	John Bogart	Clarence Cary
Adams, Blodget & Co.	Geo. S. Bowdoin	Eugene Cary
John W. Aitkin	Dwight Braman	J. F Chamberlain
Chas. W. Bangs	Brown Bros. & Co.	Thomas P. Chaney
Francis S. Bangs	Wm. L. Bull	Chas. F. Clark
August Belmont & Co.	George B. Burbank	C. H. Coster

DOMESTIC ASSOCIATES—CONTINUED

Chas. G. Curtiss
Elizabeth S. Delano
Chauncey M. Depew
Henry W. Dodd
Charles Fairchild
John G. Floyd
Chas. B. Gaskill
Chas. W. Gould
P. H. Griffin
C. J. Hamlin
Edmund Hayes
John N. Herriman
Clemens Herschel
Chas B. Hill
Wm. H. Hill
Charles Holt
Mary A. B. Howe, Executrix
Wm. S. Humberg
Brayton Ives
Frederic B. Jennings
Morris K. Jesup
Walter Katté
Geo. H. Kent
Kuhn, Loeb & Co.
Adolf Ladenburg
Chas. Lanier
Jos. Larocque
John Howard Latham
F. C. Lawrence, Jr.
Lehman Bros.
A. J. Forbes-Leith
Arthur H. Masten
John G. McCullough
Darius O Mills
J. Pierpont Morgan
Geo. A. Morrison
Chas. McVeagh
J. L. Norton
Trenor L Park
H. K. Pomroy
Albert H. Porter
Alexander J. Porter
Geo M. Porter
Wm. B. Rankine
Spencer W. Richardson
Edward L. Rogers
Winthrop Rutherford
John Satterfield
John N. Scatcherd
J. F. Schenck
W. L. Scott
Isaac N. Seligman
Coleman Sellers
Francis Lynde Stetson
F. K. Sturgis
Chas. A. Sweet
Pascal L. Taylor
Chas. E. Tracy
H. McK. Twombly
Henry C. Valentine
W. K. Vanderbilt
Van Emburg & Atterbury
Horace White
F. W. Whitridge
Edward A. Wickes
Mary F. Wickes
Edward Winslow
Winslow, Lanier & Co.

FOREIGN ASSOCIATES

Alexander Hargreaves Brown, London
Ernest Cassel, London
W. Brodrick Cloete, London
Robert Fleming, Dundee
Louis Ferdinand Floersheim, London
Leon Gotz, Paris
Hottinguer & Company, Paris
C. C. MacRae, London
F. Nettlefold, London
Henry Oppenheim, London
Francis Pavy, London
Railway Share Trust Company, London
Lord Rothschild, London
Louis Schott, London
Robert R. Symon, London
Trustees, Executors & Securities Corporation, Ltd., London
Theo. Turrettini, Geneva

The total number of "money subscribers" was 103, including those of London and Paris. About half of the subscribers purchased one "block" only, representing $6575 cash, for one share of the cataract company and $7250 par value of bonds of the Niagara company, as already more particularly described.

Additional bonds and stock, all of the Niagara company, were issued to the stockholders of The Cataract Construction Company upon their subscription therefor, at various dates and under various terms, as here described.

Date	Circular	Par Value		Cash Realized
		5% Bonds	Stock	
1890, Jan'y 17	No. 1	$2,900,000	$	$2,610,000
1893, Feb'y 15	No. 19	1,000,000	1,000,000	1,200,000
1896, Dec. 15	No. 36	2,600,000	500,000	2,000,000
1898, Apr. 9	No. 47	418,000		376,200
1899, Sept. 30	No. 49	278,000	31,000	272,100
Total		$7,196,000	$1,531,000	$6,458,300

The total cash paid for the securities of The Niagara Falls Power Company was equivalent to par ($100) per share, for the stock and about 69 per cent for the five per cent bonds.

Brought forward	$6,458,300
Under circular No. 16, of June 10, 1892, subscriptions were received at par for the Preferred Shares of the Development (land) Company and the Junction Railway Company, aggregating	561,200
The stockholders of The Cataract Construction Company paid, in 1890, the par value of the 500 shares of capital stock of $50 each	25,000
Thus, from 1890 to 1900, both inclusive, their subscriptions for bonds and shares as shown above amounted to	$7,044,500

for which they received (in addition to the Preferred Shares of the Development and the Junction Railway companies) the following securities of

	1st Mortgage Bonds	*Capital Stock*	*Cash*
The Niagara Falls Power Company	$7,196,000	$1,500,000	$
During the same period 1890–1900, interest on bonds, so subscribed for, was paid in bonds of The Niagara Falls Power Company at par to the extent of	1,386,000		
and there were distributions of construction profits, paid as dividends upon the shares of The Cataract Construction Company . .	250,000	1,800,000	264,750
Upon liquidation of The Cataract Construction Company there was returned to the stockholders in cash the $50 par value of their stock			25,000
Total cash and securities of The Niagara Falls Power Company issued to stockholders of The Cataract Construction Company upon subscriptions, for bond interest, distribution of profits and reimbursement of capital stock	$8,832,000	$3,300,000	$ 289,750

THE CATARACT CONSTRUCTION COMPANY

On January 1, 1900, The Cataract Construction Company, after ten years of activity as the agent of The Niagara Falls Power Company, surrendered its representation, retired from business and went into liquidation, having finished its construction contracts and disbursed its profits to its stockholders.[1]

Thereafter the Niagara company availed of its credit then fully established, financed its own operations, and took over the management of its own property.

The "money subscribers," as they were called, were mostly Americans. No public issue of shares or bonds was made either in this country or Europe, although representative foreign capitalists became interested, to a moderate amount, mainly through the subscriptions of their New York correspondents.

The subscriptions were represented by the promoters of the enterprise as speculative investments. The financial risks were deliberately made comparatively small in amount, $6575 cash for each participant. The venture was expected to be slow in developing. There were many uncertainties involved in the decisions to be made as to the systems and machinery to be adopted.

The organization of capitalists and engineers became an association of adventurers and pioneers. The participants were advised to take only such small amounts as would maintain and stimulate their interest in the methods adopted in harnessing Niagara, but could not cause anxiety or serious regrets.

The importance of the experiment was recognized. It was an interesting problem; its solution would be important and historical. Its success would be of national interest and a source of gratification and pride to its venturers. Each financial participant might at least experience satisfaction as one of few who did much for many in thus developing the industrial resources and advancing the prosperity of this country.

FOREIGN INVESTIGATIONS

Not long after the formation of the syndicate of "money subscribers," President Adams of The Cataract Construction Company was in London seeking information regarding the most recently established power systems in Europe. Desiring an influential introduction and advice as to what engineering groups in England should primarily be consulted, he called, as had been his custom for many years when visiting "the City," upon Lord Rothschild, the international banker. President Adams explained the project for the utilization of Niagara Falls and the desire of the directors to be sure of their complete knowledge of the state of the arts they were likely to employ,

[1] Chapter XII.

before adopting a definite plan, organizing a company and selecting its executives to design, estimate and construct the undertaking.

After suggesting names of experts and outlining their professional experiences and standing, Lord Rothschild gave a key introduction and remarked substantially as follows:

"I suppose you are not ready with your financial plans?"

"Yes," replied President Adams, "they have been adopted to a preliminary extent. We find the project very interesting; it has many problems; all previous efforts to utilize Niagara power in an important way have been failures, but we believe that science has so advanced that, with its skillful use, it may soon be possible to harness Niagara upon a commercial basis. We have resolved to engage in the experiment."

"I presume," the English banker continued, "you will wish to discuss your financial plans?"

"Not exactly, sir. We have not come for money, but for advice. Our immediate and contiguous requirements have been provided, and we wish to begin by investing in the counsel of your scientists and engineers."

"Well," said Lord Rothschild, "this is something new, indeed. Rarely in my experience have foreign capitalists come to London to spend their own funds for information as to how to invest their own money in their own country. I should like a participation in your experiment and will gladly assist you in every possible way."

It is noteworthy that from the original £5000 subscribed as a result of this interview, a considerable investment resulted from a proportionate participation in subsequent subscriptions and that the securities were held intact for a long period.

FINANCIAL DOCUMENTS

Among the important links in the chain of events that bound the adventurers together, there follow here:

1. Certificate of Syndicate Subscription issued under the Agreement of Money Subscribers of January 17, 1890;
2. Circular No. 2 issued February 3, 1890, by The Cataract Construction Company to its stockholders, reporting progress;
3. Circular 10a, being an extract from the Directors' Minutes of December 24, 1890, exercising option to pay interest on money subscription in bond scrip during construction;
4. Certificate of First Mortgage Bond Interest Scrip.

$5,000.
Cash

No. 000

SUBSCRIPTION CERTIFICATE

New York,
February 1st, 1897.

TO

$6,500. FIRST MORTGAGE BONDS

$1,250. CAPITAL STOCK

OF

THE NIAGARA FALLS POWER COMPANY

The bearer will be entitled to receive after payment of . . . .
FIVE THOUSAND DOLLARS, ... pursuant to the terms of subscription under circular No. 36 of December 15th, 1896, of this Company,

$6,500. First Mortgage 5% Bonds,
bearing interest from January 1st, 1898, and
$1,250. Capital Stock of

THE NIAGARA FALLS POWER COMPANY.

The Capital Stock will be deliverable after payment of $2,500. and the Bonds after payment of the entire subscription of $5,000. and the surrender hereof at the office of this Company in the City of New York.

All payments must be evidenced by the endorsement of this Company hereon

THE CATARACT CONSTRUCTION COMPANY,

Countersigned by | by
(Specimen) | (Specimen)
. . *Secretary* . *President*

THE CATARACT CONSTRUCTION COMPANY

Circular 2.

MILLS BUILDING, 23 BROAD STREET,
ROOM 24, Fourth Floor,
NEW YORK, February 3, 1890.

DEAR SIR:

You are hereby notified that under clause 1, of the subscription of January 17, 1890, this Company is prepared to issue to you shares of stock, upon receiving at the New York office of the Company (as above) *your cheque to the order of* GEORGE H. KENT, Treasurer, *for fifty dollars a share, being in all* $

There is herewith enclosed, strictly for your personal use, (1) a copy of the Syndicate Subscription of January 17, 1890, and (2) a copy of the Statement of the Financial basis of that subscription.

To avoid confusion it is proper to state that these two papers constitute and comprise the exclusive foundation for subscription, the green pamphlet of 1886 and the "Memorandum" printed (though never officially issued) in the summer of 1889 having been

superseded and withdrawn in view of the proceedings at the subscribers' meeting, January 14, 1890. At that meeting Dr. Sellers reiterated his approval (since confirmed by the Hydraulic Engineer, Clemens Herschel, Esq.), of the agreement of December 30, 1890, granting a right of way under the Hydraulic Canal defeasible only in case of unremedied damage to the canal, or failure to deliver the $15,000 in bonds (provided for in the financial statement).

The promised agreement for right of way under the Central Railroad tracks is still under consideration for the purpose of embracing a number of collateral stipulations mutually advantageous.

The time for executing the formal contract with the Niagara Company has, at the request of this Company, been extended to April 1, 1890, so as to permit careful formulation of plans. At that time it is proposed to put the existing land contracts for the original 229 acres into the form of deeds with mortgages back. In cases where immediate possession is necessary, cash will have to be paid in whole or in part. In this way it is believed that every interest in the plan as originally proposed is adequately secured.

As to the additional lands authorized to be acquired at the meeting of January 14, 1890, the Company is proceeding with rapidity and gratifying success in purchases within the specified limit. The first payments are being made from a sum ($60,000) advanced by Mr. Adams, who, after consultation before sailing, advised that all steps be taken for securing these various interests and for establishing the enterprise without waiting for further subscriptions. In the opinion of some subscribers further subscriptions should be postponed so as to give present subscribers an opportunity to increase.

A meeting of the subscribers, for the purpose of completing organization, choosing a Committee of Three, and for any other business, will be held at the New York office of the Company, Room 24, Fourth Floor, Mills Building, at 3 o'clock P. M., on Thursday, 6th February, 1890.

WILLIAM B. RANKINE,
Secretary.

Circular 10a.

EXTRACT FROM MINUTES OF DECEMBER 24, 1890.

Whereas, In the subscription agreement of January 17, 1890, by the form of certificate therein set forth as well as by the financial basis dated 23d January, 1890, it was provided that scrip or bonds might, at the option of Cataract Company, be paid for interest accruing during construction upon any and all payments upon subscriptions to such agreement; and

Whereas, At a meeting of the money subscribers held February 6, 1890, it was voted that for all purposes of the agreement of January 17, 1890, assent in behalf of the money subscribers might be given by the regular action of the Board of Directors of this Company, which resolution was duly notified to all parties in interest by circulars 3 and 3*a* ; now therefore be it

Resolved, That the Cataract Company hereby exercises its said option, and hereby declares and decides to pay interest during construction by the issue of scrip certificates, substantially in the form of that hereunto annexed, redeemable in bonds as therein provided.

Resolved, That in case any coupons upon any bonds held by the Committee under Clause 5 of the agreement of January 17, 1890, shall mature before the completion of the first section of the works of the Niagara Company, the Committee shall be and it is hereby authorized and directed to detach such coupons, and to deliver or dispose of such bond without such coupons, which with all other coupons of the same maturity shall be held by such Committee until the interest thereby represented shall have been duly adjusted, by the issue and redemption of scrip certificates as herein provided; and in case of bonds without coupons the interest before completion shall be similarly paid and adjusted, and the committee shall suitably inscribe such bonds accordingly.

Resolved, That a copy of these resolutions be forthwith communicated to each money subscriber.

No..................

CERTIFICATE

OF

THE CATARACT CONSTRUCTION COMPANY

FOR $..............................

OF

THE NIAGARA FALLS POWER COMPANY

FIRST MORTGAGE INTEREST SCRIP

THIS IS TO CERTIFY, That..

a subscriber to a certain agreement with The Cataract Construction Company, bearing date January 17, 1890, or the transferee hereof, will be entitled, subject to the terms of said agreement, to receive from the Committee under Clause 5 of said agreement, at the time and in the manner therein provided for the delivery of bonds, or proceeds of bonds, the sum of

dollars,

without interest thereon, in First Mortgage Bonds of The Niagara Falls Power Company, or the proceeds of such bonds, provided that no such bonds or proceeds shall be deliverable on account hereof, except upon surrender to the Committee of scrip certificates of this tenor, in aggregate amount equal to the par value of such bond.

This Scrip Certificate is issued and received on account of interest accruing up to 1st, 189 , under and upon the payments heretofore endorsed upon Subscription Certificate No. and shall, when redeemed without interest, as herein provided, be in full satisfaction of all claims for such interest to the extent above certified. All transfers hereof, before taking effect, must be registered by the Company.

In Witness Whereof, The Cataract Construction Company, has caused this Scrip Certificate to be signed and delivered, by its President (or Vice-President) and its Treasurer, and to be duly registered, this 1st day of , 189 .

President.

Treasurer.

PROGRESS OF CONSTRUCTION AND ITS FINANCE

The basic features of this enterprise were experimental and practically all were involved in the installation and operation of three units of 5000 horse-power each in the sections of the Power-house and Wheel-pit Slot Number One first constructed. This installation was a demonstration, and its resulting actual income and that prospective from contracts assured, when made public, announced to the world that the Niagara problem had been commercially solved.

BOND BUYERS

Circular No. 36 of The Cataract Construction Company, issued December 15, 1896, stated that "the works of The Niagara Falls Power Company are so far completed that delivery of power to customers in Buffalo has been successfully instituted, and that the calls for power under contracts actually executed (and in excess of the present capacity of the works) will provide annual rentals of $365,975, and, under contracts in negotiation, $72,250 more, or a total of $438,225," much more than previously estimated.

The circular further stated that

> since work has begun in 1890, no interest in The Cataract Construction Company is known to have been sold for less than par; notwithstanding the occurrence of at least four financial crises in the principal money markets of the country, and other influences deterring the establishment of many new industries requiring power. Considering these general and well-known adverse conditions, coincident almost with its life, the wonder is that this company has so steadily progressed, and, as above indicated, has almost reached the point of self-support. Under such conditions, and in view of the necessarily experimental character of the work, it would have been folly at any earlier date to seek to provide for an installation larger than necessary to demonstrate that this enterprise can accomplish real work and promise real profits, such as can now be expected after January 1, 1898

To complete the power-house and wheel-pit slot for the ten units of a total 50,000 horse-power, involved an estimated additional expenditure of $2,000,-000, and this program was announced as follows:

> The proposed extension involves doubling the present capacity of the transmission line to Buffalo which is now delivering 1000 electrical horse-power; the extension of the wheel-pit for its full length, so as to have capacity in all for ten 5000 horse-power turbines and dynamos; the installation of seven 5000 horse-power turbines and dynamos, in addition to the three now in operation, and the extension of the power-house to cover the new installation.
>
> Such an extension of the wheel-pit is about one-third completed; the right-of-way from Niagara Falls to Buffalo is completed, the pole-line already erected has a pole and cross-arm capacity of 20,000 electrical horse-power, with copper conductors in place for 5000 electrical horse-power. Upon definite proposals already received, the

entire installation above described can be progressively completed before April 1, 1898, with the proceeds of the subscription of $2,000,000 now invited, and already largely taken.

This subscription for bonds and stock of The Niagara Falls Power Company was divided into blocks of $5000 each, for $6500 par value of first mortgage five per cent bonds and $1250 par value of capital stock. This was the last subscription for the combined securities offered by The Cataract Construction Company.

Circular No. 47 of April 9, 1898, offered $418,000, and Circular No. 49, of September 30, 1899, offered $278,000 of bonds, in both instances at 90 per cent of their par value and accrued interest.

THE NIAGARA FALLS POWER COMPANY

After the conclusion of the construction of its principal works, undertaken, financed and completed by The Cataract Construction Company, in 1899, when it surrendered its agency and ceased its activities, the financial negotiations of The Niagara Falls Power Company commenced with the issue of its Circular No. 50 of November 16, 1899, in which the progress of the enterprise may be seen by its statement that

the limit of the present power-house and the present wheel-pit upon the west side of the canal has been reached, and additional turbines and dynamos can be established only by the construction of an additional wheel-pit and an additional power-house, for which a site upon the east side of the inlet-canal, approved by the professional advisers of the company, has been adopted by the board of directors.

In anticipation of this demand for power, the supply of water by the inlet-canal, and its discharge by the outlet tunnel had been originally constructed with a capacity of 100,000 horse-power.

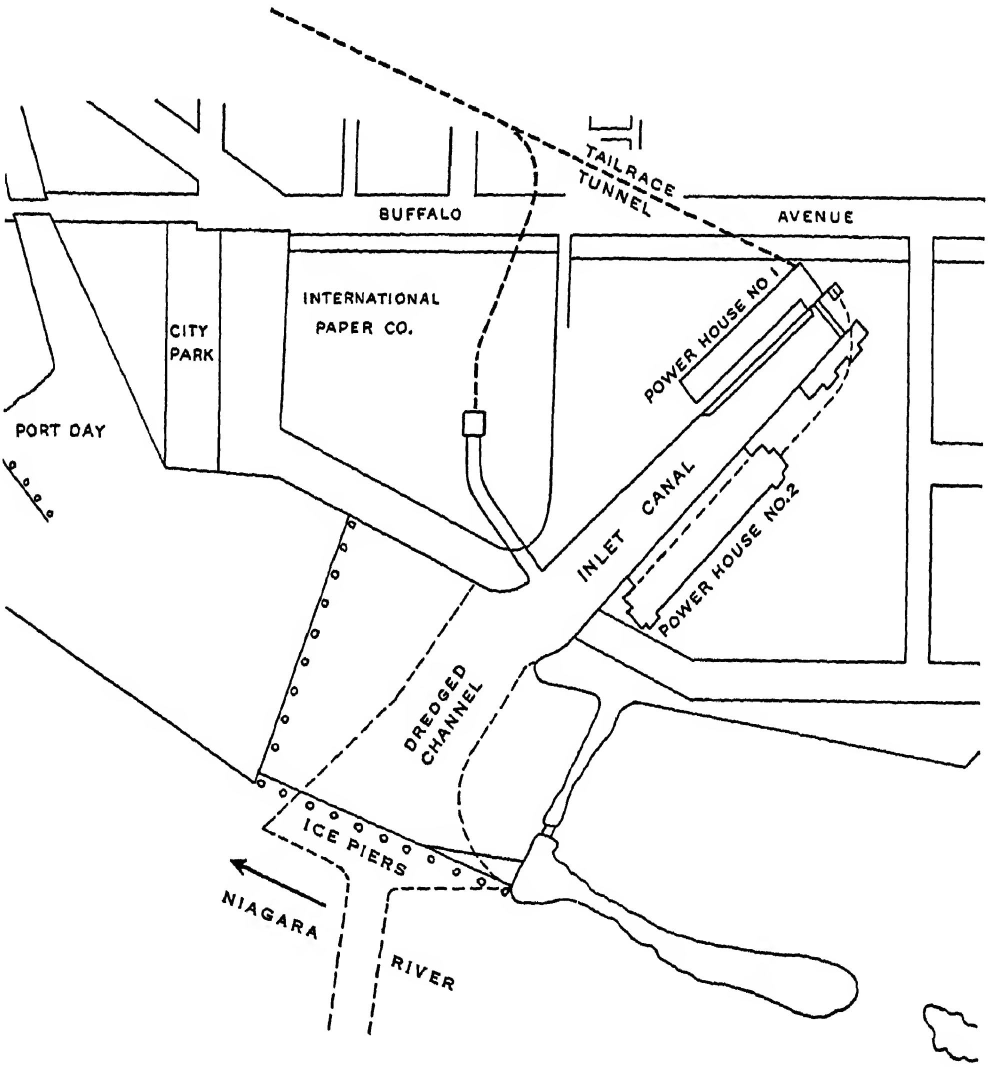
POWER-HOUSE NUMBER TWO

The plan on the next page prepared in 1892 indicates two power-houses of 50,000 horse-power each, one on the east side of the inlet-canal for hydro-electric, and the other on the west side for hydro-pneumatic development. By 1899, however, the electric system operated from Power-house Number One had fully proved its reliability and advantages, while the pneumatic method had nowhere fulfilled its early promises. The Niagara Falls Power Company announced its unreserved commitment to hydro-electric methods for the development of the 200,000 effective horse-power that it was authorized to utilize from the waters of the Niagara River.

The improving credit of the company prompted the directors to reserve its mortgage securities as a future resource in event of need, and to create an issue of $3,000,000 six per cent, ten-year convertible debenture bonds,

without special pledge of property or mortgage lien with the right in the holder, at his pleasure on any interest day, on or before April 1, 1905, to convert the same at par into the capital stock of The Niagara Falls Power Company at par.

Subscriptions were invited for the purchase of $2,100,000 at par and accrued interest, leaving $900,000 for subsequent issue as required. It was directed



Location of Inlet-canal and Power-houses

that the construction of the second wheel-pit should be that eventually to be required for eleven turbines and dynamos, of which six units should be ordered then, leaving five for later installation.

By its circular No. 56 of June 25, 1901, The Niagara Falls Power Company informed its stockholders that the construction of the wheel-pit of the additional power-house upon the east side of the canal, authorized in November,

1899, had progressed so that the six dynamos would be in operation by March, 1902, in anticipation of which a considerable portion of their power had already been contracted for upon remunerative terms. Convinced of further demands for considerable power for increased use by present tenants and by the new chemical and metallurgical industries, the directors urged immediate preparation for the development of power by the Canadian Niagara Power Company, of which The Niagara Falls Power Company owned the entire capital stock except the qualifying shares of the directors.

CONSTRUCTION AND FINANCE OF POWER-HOUSE NUMBER THREE

The Canadian company was authorized to create and utilize power within the Queen Victoria Niagara Falls Park, and to transmit the same without the park, with authority to construct and operate works necessary and useful in connection with the business of The Niagara Falls Power Company.

The company's circular further stated:

> The Canadian company has authority to take its lines or conductors across the bridges over the Niagara River, and the power developed by it may be used as a reserve and also as an addition to the power developed upon the American side by the connection of the power-houses on the two sides of the river, providing each user of power from either power-house the protection of reserve power from the other power-house

The accepted and final plans of the Canadian company provided for "the construction of the main tunnel with capacity of not less than 100,000 horse-power; an intake-canal with the capacity of 50,000 horse-power; and a wheel-pit with present capacity for 25,000 horse-power of hydraulic and electrical machinery. The estimates of the engineers indicate that $2,700,000 will be sufficient to cover the cost of such works, including a power-house, generating and transforming machinery sufficient to enable the company to supply 20,000 electrical horse-power for transmission without the Park, and also including interest during the period of construction, estimate to take two years."

In order to provide the necessary capital, an additional issue of ten-year six per cent convertible debenture bonds was authorized by The Niagara Falls Power Company, to be secured by the same amount of debentures to be issued by the Canadian Niagara Power Company, under a first mortgage covering all its property in the Queen Victoria Niagara Falls Park.

Subscriptions to $2,700,000 of such secured debentures at par and accrued interest were invited from the stockholders.

On February 14, 1903, The Niagara Falls Power Company announced to its stockholders by its Circular No. 62 that the first six units of 5000 horse-power each, previously authorized, had been installed in wheel-pit and

Power-house Number Two, built for eleven units and contracts had been authorized and let for the other five units of 5000 horse-power each.

To provide funds for the completion of this second installation in Power-house Number Two, and other works authorized, subscriptions were invited for the purchase of $800,000 of the six per cent ten-year convertible debentures, due April 1, 1910, at the price of par and interest.

Soon after the construction of the Canadian plant commenced, there were such demands for power that the construction program was enlarged, and on December 10, 1904, Circular No. 68 was issued to the stockholders of The Niagara Falls Power Company, stating that the $2,700,000 provided under Circular No. 56 had been expended in the construction of:

a main tunnel, completed, with a capacity of 110,000 horse-power;

an intake-canal, completed, with a capacity of 110,000 horse-power;

a wheel-pit slot, completed, with a present capacity of 50,000 horse-power;

an extension, under construction, with capacity of 60,000 horse-power additional; and

a power-house, completed, with generating units being installed that would supply 50,000 horse-power.

Fully to provide for the estimated cost to complete the works of enlarged capacity, the stockholders were invited to subscribe, at 95 per cent and accrued interest, to an additional issue of six per cent debentures of The Niagara Falls Power Company, to the extent of $2,000,000, secured by a like amount of Canadian debentures, to be issued under the first mortgage upon the property of the Canadian company. These debentures were payable November 1, 1914, and subject to redemption, at the option of the company, after October 1, 1911, but they were not convertible similar to the previous issue, into the capital stock of The Niagara Falls Power Company, and were specially designated as "Series B."

After the lapse of more than two years, Circular No. 69, dated January 12, 1907, was issued by The Niagara Falls Power Company, inviting the stockholders to subscribe, at the price of 90 per cent and accrued interest, to $1,500,000 of its six per cent debentures, payable November 1, 1914, but redeemable October 1, 1911. This issue was known as "Series C" and was secured by a like amount of debentures of the Canadian company that were issued under a lien upon all its power-plant rights in the Queen Victoria Niagara Falls Park, franchises, power transmission lines, and other property then owned or thereafter acquired for its corporate purposes, and necessary

or useful in the development, transmission, distribution or delivery by it of the electrical power generated in its plant, subject only to the prior lien of the mortgage of October 1, 1901, securing the issue of $5,000,000 Canadian company debentures (Series A and Series B).

INTER-CONNECTION OF THE THREE POWER-HOUSES AND TRANSMISSION TO BUFFALO

The Niagara company announced at this time that the construction of Power-house Number Three, commenced in Canada, December, 1904, had been completed, that there were in operation five power units of 10,000 horse-power each, and the head works, wheel-pit slots and tunnel, then completed, had a capacity for service of an aggregate of eleven similar units.

It was also stated that a 32-duct conduit from the Canadian power-house was then connected at the international boundary, Niagara Falls, New York, with a similar conduit extending to a connection with cables installed in the American plant, for the transmission of 32,000 horse-power; and that two overhead power transmission circuits had been constructed along a private right-of-way acquired by the Canadian company extending from its power-plant at Niagara Falls, Canada, along the Canadian side of Niagara River to Fort Erie, opposite Buffalo, New York, cables being extended thence to a terminal station of the Cataract Power and Conduit Company in the city of Buffalo. About 12,000 horse-power, it was stated, were then being delivered from this transmission line regularly for use in Buffalo, and it was proposed, at an early date, to supply 25,000 horse-power from these circuits to Buffalo, thus allowing the American plant to enlarge its services in its adjacent territory of Niagara Falls and Tonawanda. The pre-emption by other Canadian power companies of sites available for manufacturers at Niagara Falls, Canada, had made it necessary for the American and Canadian Niagara companies to purchase a considerable amount of real estate on the Canadian side.

REFUNDING AND GENERAL MORTGAGE BONDS

At a meeting of the stockholders of The Niagara Falls Power Company, June 1, 1909, the execution was authorized of a "Refunding and General Mortgage" to secure an ultimate issue of $20,000,000 six per cent bonds, to become payable January 1, 1932. The principal purpose of this issue was the timely provision to meet the payment at maturity in 1910 and 1911 of $6,000,000 of the company's debentures, as well as all the other bonded obligations maturing in no distant periods thereafter.

On February 26, 1910, an offer was made to retire the six per cent debentures of The Niagara Falls Power Company of the several issues, aggregating

a total of $9,076,000, by an even exchange for the new refunding and general mortgage six per cent bonds, due January 1, 1932. During that year, $7,542,000 six per cent debentures of The Niagara Falls Power Company were refunded, as proposed, and in the following year the remainder were provided for by a sale of the company's capital stock at par, the company having availed of its option, reserved in the original issue, to redeem the debentures prior to maturity.

Circular No. 75, of May 11, 1910, offered to the stockholders $686,000 of the company's six per cent refunding and general mortgage bonds at par and accrued interest, to pay for additions and improvements to the plants of The Niagara Falls Power Company and the Canadian Power company.

CAPITAL STOCK SOLD AT PAR TO RETIRE BONDS

An issue of $1,534,000 par value of the capital stock was authorized in March, 1911, and subscribed for at par in cash by the stockholders of The Niagara Falls Power Company, by the terms of its Circular No. 77, for the express purpose of retiring that amount of debentures (Series A, B and C, Canadian collateral), called for redemption under the terms reserved to the company, prior to their maturity.

During the year 1911, the entire capital stock, 2500 shares ($250,000 par value) of the Tonawanda Power Company, was acquired in an even exchange for the shares of The Niagara Falls Power Company.

SALE OF CONTROL OF BUFFALO AND TONAWANDA FILIAL COMPANIES

Under date of June 1, 1915, the ownership of 10,050 shares ($1,005,000 par value of a total $2,000,000) of the capital stock of the Cataract Power and Conduit Company, of Buffalo, was sold by The Niagara Falls Power Company to the Buffalo General Electric Company at 141 per cent, payable in cash and its first refunding five per cent bonds, due 1939, at par and interest. The bonds were sold by the power company at 95 and interest, and the total net proceeds, $1,501,419, added to the funds of the company, held by trustees as part security for its bonds and available under the terms of the mortgages securing the bonds for construction purposes and property acquisitions. These shares were those of the company organized in 1896, to receive and distribute Niagara power in Buffalo, in which a majority interest had been retained by The Niagara Falls Power Company.

A policy similar to that established in Buffalo was pursued for the distribution of Niagara electric power from the Buffalo transmission line, as it

passed through North Tonawanda, Tonawanda and Wheatfield, from which towns licenses had been obtained therefor.

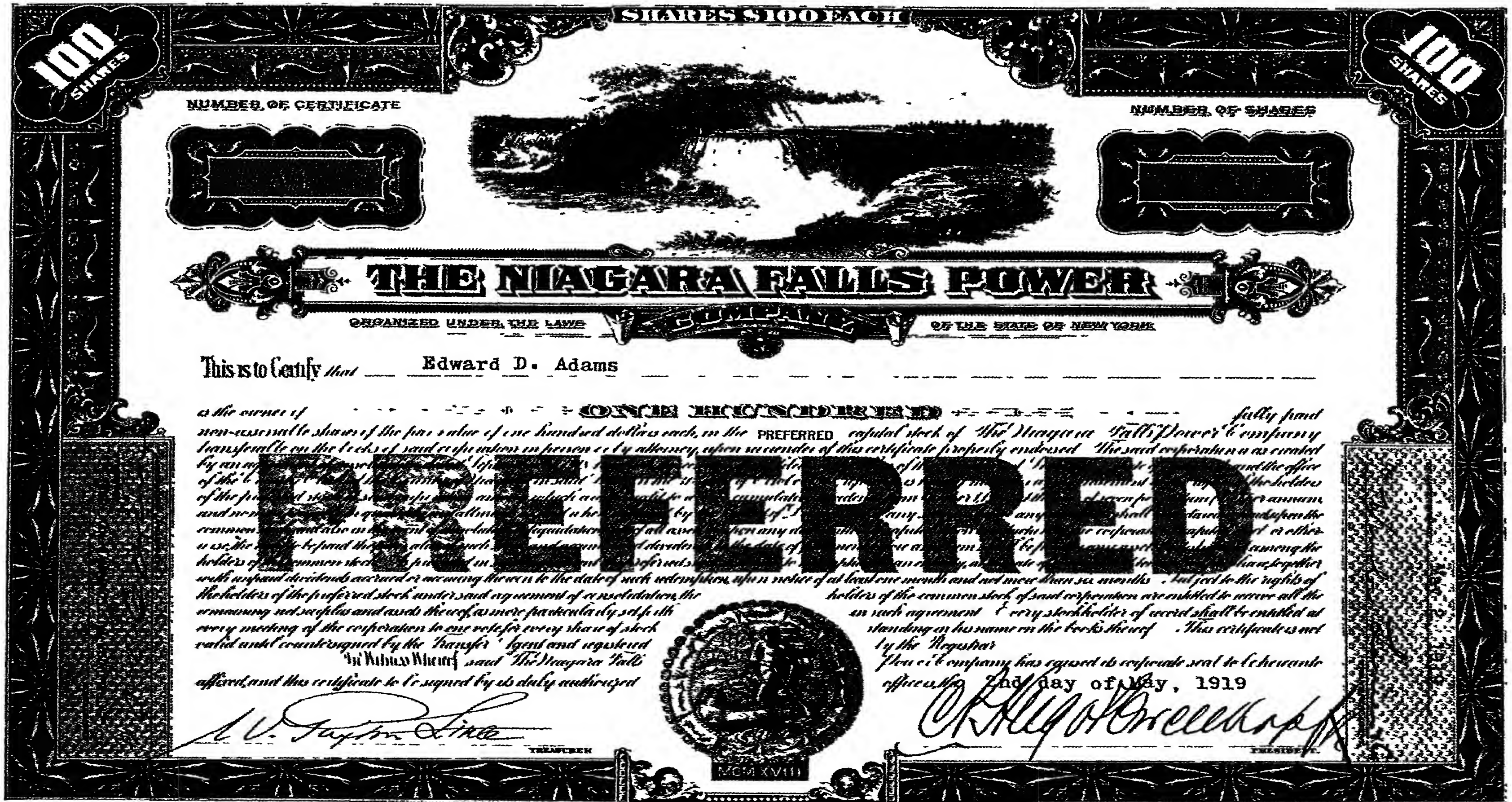
A company was formed under the name of Tonawanda Power Company, with an authorized capital stock of $250,000. Several contracts for power were awaiting action, and the necessary machinery for a transforming and distributing station for current and switching services were promptly installed. In August, 1917,[1] all of this capital stock was sold at $175 per share to local interests at Tonawanda, and $437,500 cash was paid to The Niagara Falls Power Company for its $250,000 par value, constituting all of the capital stock of the Tonawanda company.

FINANCIAL SUMMARY

As already shown, cash capital was provided through the sale of bonds and shares of The Niagara Falls Power Company, by The Cataract Construction Company, during the formative and construction period, when it was responsible for the plans and liabilities of the enterprise. Upon the completion of the construction undertaken by the cataract company, and its retirement from its representation in 1900, the financial responsibility came solely upon the management of The Niagara Falls Power Company until 1918, when its control was acquired by the consolidated company, The Niagara Falls Power Company, MCMXVIII.

The following summary of financial negotiations by The Niagara Falls Power Company indicates its financial policy, the support of its stockholders during a period of commercial crises, and the gradual improvement in its credit by establishing confidence in the method that had been adopted through the demonstration, in the operation of its works, of its reliability and profitableness.

[1] See Circular No. 84 of The Niagara Falls Power Company for the year 1917, Appendix D, Volume I.



Stock Certificate of The Niagara Falls Power Company, MCMXVIII

STOCK AND BONDS OF THE NIAGARA FALLS POWER COMPANY
SOLD THROUGH OFFERINGS TO ITS SHAREHOLDERS
1899–1911

Circular		The Niagara Falls Power Company				
Date	No.	Price	6% Bonds	Stock	Cash	
1899, Nov. 16	50	100 & Int.	$2,200,000	$	$2,200,000	Debentures
1901, June 25	56	100 "	3,000,000		3,000,000	Series A
1903, Feb. 14	62	100 "	800,000		800,000	Debentures
1904, Dec. 10	68	95 "	1,980,000		1,881,000	Series B
1907, Jan. 12	69	90 "	1,096,000		986,400	Series C
1910, May 11	75	100 "	686,000		686,000	Ref. Gen. Mtg.
1911, Mar. 27	77	100		1,534,000	1,534,000	Shares
		Par Value	$9,762,000	$1,534,000		
				Total Cash	$11,087,400	

Debentures redeemed		$9,076,000
1. By Refunding and General Mortgage 6% Bonds, issued in exchange at par	$7,540,000	
2. By Cash Payments	1,536,000	$9,076,000

The total amount of cash for construction purposes, raised from organization in 1889 to consolidation in 1918, amounted to $20,270,820, and was provided as follows:

		Cash Proceeds
The Cataract Construction Company		
Offered Its Stockholders for Subscription		
Capital Stock		$ 25,000
Securities Sold		
The Niagara Falls Power Company Bonds		6,458,300
Niagara Junction Railway Company Preferred Stock		140,000
Niagara Development Company Preferred Stock		421,200
		$ 7,044,500
The Niagara Falls Power Company		
Offered Its Stockholders for Subscription		
Securities Sold		
Bonds and Shares of Power Company	$11,087,400	
Shares of Power Company	200,000	
Stock of Tonawanda Power Company	437,500	
Stock of Cataract Power and Conduit Company of Buffalo	1,501,420	13,226,320
Total Cash Provided		$20,270,820

During this period The Cataract Construction Company provided the necessary funds for its work, and distributed its construction profits as dividends to its stockholders in cash and bonds and shares of The Niagara Falls Power Company.

The Niagara Falls Power Company commenced the payment of cash dividends upon its capital stock, as outstanding from time to time, at the rate of eight per cent per annum by the declaration of a distribution of profits in April, 1910, at the rate of two per cent quarterly, that was continued without interruption until the consolidation of the companies in the autumn of 1918, when an extra dividend of three per cent was paid, the capital rearranged and the management changed. There were thirty-six dividends paid in cash from April, 1910, to October, 1918, a total amount of $4,047,101.

CONSOLIDATION OF POWER COMPANIES

The consolidation of The Niagara Falls Power Company with the Cliff Electrical Distributing Company and the Hydraulic Power Company of Niagara Falls, carried out by The Niagara Falls Power Company and the Hydraulic Power Company of Niagara Falls, was contracted by all parties in interest under date of September 20, 1918, the consolidated company receiving the title of *The Niagara Falls Power Company.*

The advent of the Schoellkopf interest in the ownership and management of the consolidated company, brought to a conclusion the financing of the enterprise, commenced in 1889 by The Cataract Construction Company and carried out by The Niagara Falls Power Company from 1900 to the consolidation of 1918.

The exchange of shares of The Niagara Falls Power Company for those of the consolidated company was accompanied by the delivery to the latter of the cash, current assets and investments of The Niagara Falls Power Company and its filial organizations, amounting as of September 30, 1918, after providing for all current liabilities, to $5,583,592, comprising its surplus, unimpaired reserves and undivided profits, being $3,551,800 cash and cash assets, $1,774,552 in bonds of the United States Government, and $257,240 in Victory Loan of the Dominion of Canada.

PUBLIC ATTITUDE

In financing the Niagara enterprise it was foreseen that incredulity would be an obstacle to credit, because the methods to be used would be those of pioneers, and the history of attempts to develop Niagara power had been largely a record of failures. Complete financial provision was therefore made at the beginning of the undertaking so that no public appeal for money would have to be made, if at all, until after the Niagara company had established its credit by net profits in the operation of its plant. Its stockholders had been carefully selected because of their confidence in the organization and their financial strength to carry their share of the adventure through to its completion.

NO PUBLIC APPEAL FOR MONEY IN PIONEER STAGE

Bankers in Buffalo naturally traded in such securities as were obtainable from original subscribers, and in creating their markets gave such information as they could gather, but this was restricted by the policy of the cataract company to announce officially only the *fait accompli.* The magnitude of the enterprise, the novelty of the methods of development, and the dangers to life and fortune, engendered grave doubts that appealed to prudence when

opportunities were presented of sharing the financial risks of the original parties.

Each visitor, of the many tourists at the falls, judged of the enterprise according to his own experience, which in comparison with what could be learned of the new project, created distrust of the unseen and doubt of the unknown.

The following correspondence indicates this attitude of some of the public during construction.

A dealer in local investment securities, in Buffalo, wrote in March, 1893, asking for information about the Niagara project, stating that "Not only people here, but in many parts of the country, are taking great interest in your project, and I receive many letters regarding it."

An investor in a neighboring city wrote, in answer to an offer of securities of The Niagara Falls Power Company:

> I confess I cannot quite understand the strong statements made by the experts and printed matter. Is it not true that no such enterprise was ever undertaken before and there is no precedent for what is being undertaken?
>
> Is it not true that there is uncertainty as to the effect of sending vast bodies of water down a stand-pipe with a perpendicular fall of 120 feet?
>
> Is it clear that the turbine wheels can stand it and construction stand the continuous shock?
>
> Is there not danger of breakage, accident, etc., that might seriously interfere with the project and profit?
>
> I confess although everything seems favorable, the enterprise will appear to be quite hazardous, at once calling for a very great margin of profit as inducement.
>
> If I am not right you can correct me; but I have never heard or read before of any such scheme, or of any such turbine wheels to be used. I should be pleased to know what certainty there is about the business.

The answer, in part, was, "We expect these wheels, each of 5000 horse-power, will be creating a revolution at Niagara during the coming summer."

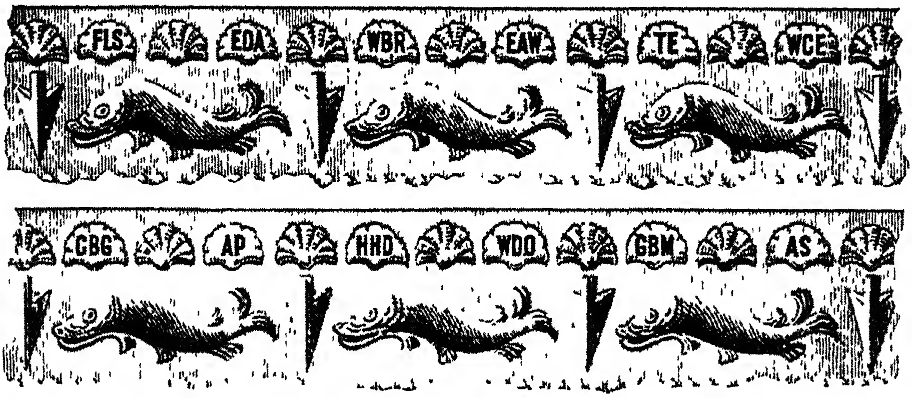
INITIALS ON STOCK CERTIFICATE

The union or consolidation of the interests, representing both property and management, is indicated on the first certificate[1] of the preferred stock issued by the new company, in the design of its seal, being that of the old company with the year of consolidation subjacent, as THE NIAGARA FALLS POWER COMPANY MCMXVIII. Moreover, the decorative border of the engraved certificate was copied from the MacMonnies seal, in which was represented the maskinonge (Esox nobilior) and the Delthyris niagarensis in the design, and in the center of each alternate fossil shell on the sides of the certificate, and in its center under the word "Company," may be read the initials of the names that

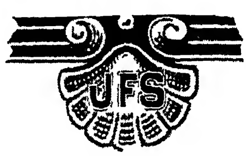
[1] See page 310.

represent the founders of the original companies, all of whose construction is now brought within the ownership of the new and single company and under the management of the second and third generations of the Schoellkopf pioneers in the harnessing of the Niagara River.

These designs have been introduced in the new certificates by the direction of the officers of the consolidated companies, and are reproduced here as an acknowledgment on behalf of the surviving associates of the courtesy thus shown to their predecessors by those who now direct the affairs of this important and growing enterprise.



J. F. S.	[1]Jacob F. Schoellkopf, President.
F. L. S.	Francis Lynde Stetson, Director of The Niagara Falls Power Company.
E. D. A.	Edward D Adams, Director of The Niagara Falls Power Company.
W. B. R.	Wm. B. Rankine, Director of The Niagara Falls Power Company
E. A. W.	Edward A. Wickes, Director of The Niagara Falls Power Company.
T. E.	[2]Thomas Evershed, Engineer.
W. C. E.	[2]W. Caryl Ely, Counsel.
C. B. G.	[2]Charles B. Gaskill, President.
A. P.	[3]Augustus Porter.
H H. D.	[4]Horace H. Day
W. D. O.	W. D. Olmsted.
G. B. M.	[5]George B. Mathews.
A. S.	[1]Arthur Schoellkopf, Vice-president and General Manager.



[1] The Niagara Falls Hydraulic Power and Manufacturing Company, 1877.

[2] Engineer, Niagara River Hydraulic Tunnel, Power and Sewer Company, 1886.

[3] Porter, Barton & Company, 1805, portage lessees.

[4] Acquired the hydraulic canal and spent a large fortune upon it, but it was eventually sold under foreclosure and he is said to have lost his entire fortune

[5] Close associate of Jacob F Schoellkopf in the hydraulic canal enterprise, and was the first president of the reorganized hydraulic power company. He retired from active interest in the power company several years ago, and now, 1926, lives in Buffalo

The history of the Niagara Falls power-plant is a demonstration of the ability of applied electrical engineering science to attain in commercial practise results predicated in large degree upon theory. In a most striking manner, it exhibits the fact that for nearly a decade electrical engineering has been established upon a basis as certain and permanent as other branches of engineering; that eight years ago—a long time in our profession—it was possible to so plan an electrical installation involving ultimately the transmission and distribution of several hundred thousands of horse-power that at the present time we can effect improvement only with respect to relatively unimportant details, the aggregate results of which, if adopted, would be hardly noticeable as affecting the cost of power.

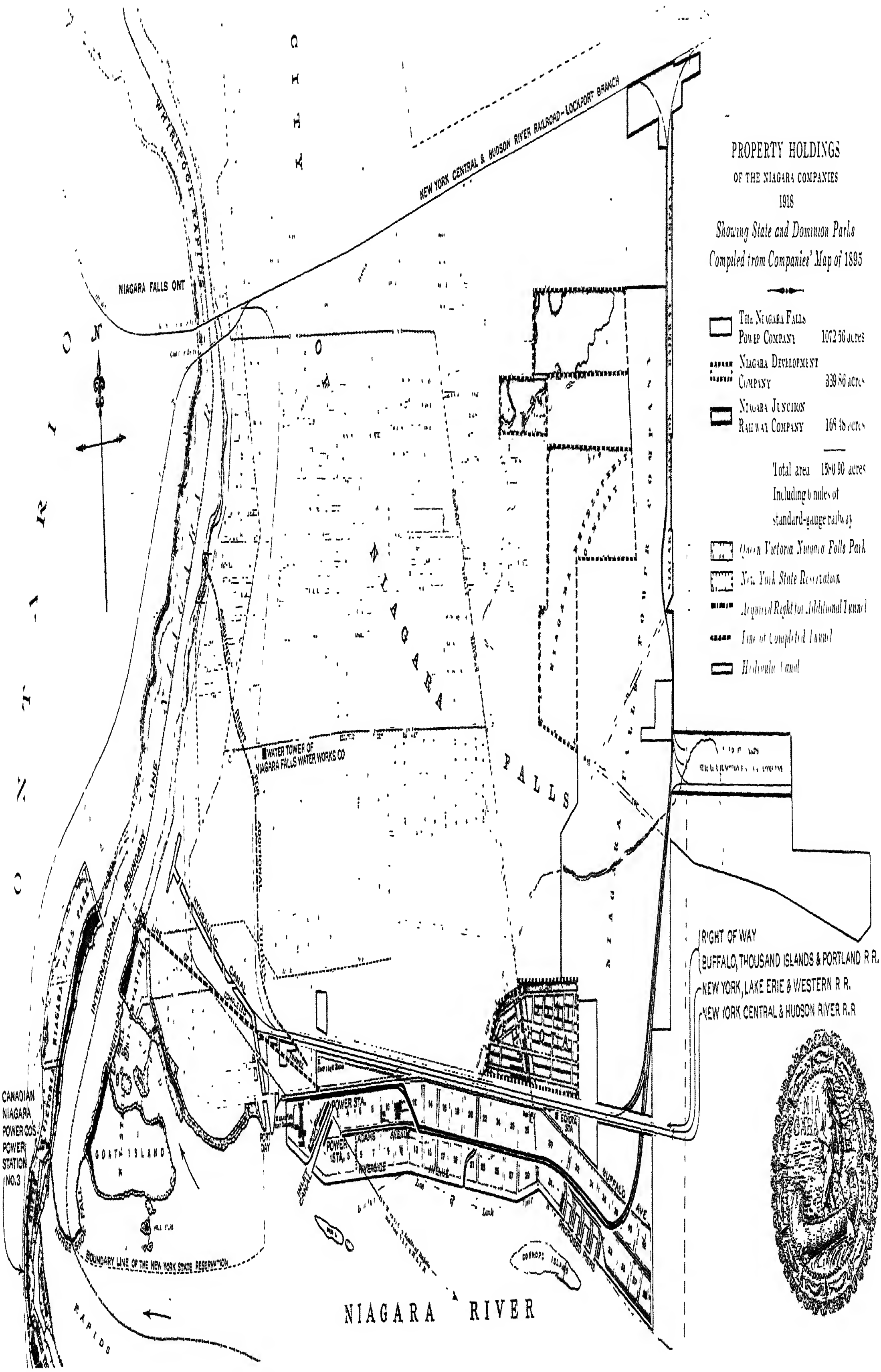
From Paper Presented by Lewis B. Stillwell to the American Institute of Electrical Engineers, August 23, 1901

THE LANDED ESTATE OF
THE NIAGARA FALLS POWER COMPANY

AND ITS FILIAL COMPANIES

NIAGARA DEVELOPMENT COMPANY
NIAGARA JUNCTION RAILWAY COMPANY

Chapter XV



Property Holdings of The Niagara Falls Power Company and Its Filial Companies before the Consolidation of 1918

Property Holdings
of the Niagara Companies
1918

THE LANDED ESTATE OF THE NIAGARA FALLS POWER COMPANY

AND ITS FILIAL COMPANIES

NIAGARA DEVELOPMENT COMPANY

NIAGARA JUNCTION RAILWAY COMPANY

CHAPTER XV

LAND REQUIREMENTS AND POWER TRANSMISSION

THE question of how much land should be acquired to provide for the use of power at Niagara was seriously considered in the early period of the study of the general problem of its development and utilization.

It was evident that as there was comparatively little land readily available near the angle of the land on the banks of the river where it would be most desired on account of economy of construction, the price would advance rapidly upon the announcement or even upon the rumor that capital had been obtained for the enterprise and the "Niagara Problem" would be solved.

Although with charter[1] power to take an unlimited quantity of river water, it was recognized that the use of power might be restricted because of such high prices for sufficient land to provide the proposed mill-sites and inlet-canals, that the initial project could not be readily financed.

Furthermore, the purchase of cheaper land upon the banks of the river above the falls would necessitate larger expenditures in inlet-canal and discharge tunnel construction in carrying out the Evershed plan of locating a water-wheel at each mill

Although ample lands, unoccupied and much lower in price, were readily available for use and could be favorably acquired in the level farming acreage north and east of the river within several miles of the village of Niagara Falls, such location would involve miles of rock excavations for water-inlet and outlet in the wheel-pit system then customary in factory construction, and the costs thereof would be impracticable if not impossible to finance.

As the Evershed hydraulic system comprising discharge tunnels, and many inlet-canals and wheel-pits in such a location must necessarily be entirely built in its major parts, before any power could be commercially developed, this location was not to be considered unless an economical system of power transmission by wire, cable or pipe could be used.

As such innovations upon long established practise could not be clearly foreseen, although then considered by some scientists as theoretically possible, it was determined to adopt a plan by which the least amount of capital would

[1] Subsequently limited to 200,000 horse-power.

be required to construct a complete hydraulic system, from the water above the falls to the water below the falls, and while this work, requiring much time, was in progress, to investigate at home and abroad the subject of development and distribution, the directors, being convinced that the power possibilities made available by such system could be made productive by one of several methods of distribution then in use or in anticipation. Hence the question whether power could be transmitted and distributed by compressed air or electricity or otherwise was the fundamental question. It involved not only the plans for the hydraulic development and the machinery to be purchased but it was the determining factor in the amount and location of the land for which provision should be made before the project was even made public.

HORSE-POWER PER ACRE AT LAWRENCE, HOLYOKE AND ELSEWHERE

The hydraulic engineer of the company advised the purchase of additional land and gave his experience with New England and other manufacturers, stating that water-power promoters seldom acquired, at the inception of their enterprises, sufficient land when cheaply available, and generally paid dearly for their lack of foresight when their undertakings developed needs of greater area than could then be readily acquired or paid for.

While the questions involved in the development of 100,000 horse-power were being considered, an examination was made of the water-powers in New England to learn about what area of land would probably be required for manufactories and dwellings, according to the experience at such localities, for the utilization of the quantity of power it was proposed to develop at Niagara. Consideration was also given to the dwellings required for the operatives likely to be brought to Niagara to be employed in the use of this power.

The following examples of special conditions were selected for guidance in this problem:

The Essex Company, at Lawrence, Massachusetts, commenced its operations with 2000 acres of land for canals, mill-sites, house lots and streets, and about 10,000 horse-power during the whole 24-hour day. This would be the equivalent per 1000 horse-power of about 200 acres, of which at least 130 acres would be required for building purposes.

The Hadley Falls Company, at Holyoke, Massachusetts, started with the equivalent of 128 acres in gross per 1000 horse-power used for 24 hours daily. Of the land about 85 acres were available for building purposes. Mill-sites required, it was stated, from 2½ to 10 acres per 1000 horse-power used upon the premises, varying, of course, with the class of work undertaken.

The average requirement at Essex and Hadley Falls is approximately 165 acres for 1000 horse-power. On this basis the land necessary for 120,000 horse-power is about 20,000 acres or 30 square miles. It may be observed that the ultimate requirements at Niagara Falls were far less than this, due to the change from the old method of driving the mill machinery directly, by water-wheels, to the new electrical method by which power is transmitted to distant places. Many of the electro-chemical processes utilizing electric power require much less space in proportion to the power used than is necessary for driving machinery.

By the census of 1880, it appeared that there were 2,732,595 operatives in manufacturing establishments in this country, using prime movers of steam and water to the total amount of 3,410,837 horse-power, being 1.24 horse-power per employee, equivalent to nearly 100,000 employees for the use of 120,000 horse-power.

The census also showed that in eight representative power-using industries, there was an average of 3.92 horse-power used for each worker employed, ranging from 13.20 horse-power per worker in flour and grist-mills, to 0.87 horse-power per worker upon worsted goods.

If 120,000 horse-power were to be used, it would require, on the basis of 3.92 horse-power per worker employed, 25,000 workers. On the basis of 13.20 horse-power per worker, 7500 employees would be necessary.

The power employed in 1889 at St. Anthony's Falls, Minnesota, a water-power development in several industries suitable for Niagara, was as follows:

	Horse-power per Hand Employed
Flouring and Grist-Mill Products	13.20
Lumber Mills	5.56
Paper	5.07

Allowing 12 horse-power per employee, it appeared that provision should be made for living conditions for 10,000 employees at Niagara, according to the established usage of a mill over its wheel-pit. Such an increase of population would require provision on a similar scale for dwellings, potable water, sewerage, light, fuel and transportation.

Dwellings and homes for men working at the falls were scarce and difficult to procure, and the demand for houses for mechanics and others who desired to locate there was increasing daily.

Niagara Falls at that period, 1890, had a population of about 10,000.

Similar estimates from other industrial centers of production, per worker and per horse-power, showed clearly that provision should be made for railway

yards, sidings and connections with the two principal American trunk lines entering the Niagara manufacturing district.

From a forecast of the situation at Niagara Falls, as these essential needs developed from the construction of the first section of the proposed hydraulic system for 20,000 horse-power available for distribution, it was evident that real estate and rents would have a rapid and important advance. The company's expenditures would enhance the market value as well as the taxable value of real estate, including its own holdings. Therefore the company should increase its land ownership without delay, and such purchases should be made only as would provide for conveniently located dwellings for some of its officers and employees, and for the construction of a standard-gauge junction and terminal railroad, in addition to what land was necessary for the power-plant proposed.

Because of the uncertainty as to the system of power transmission that would be adopted, ranging from a hydraulic turbine and shaft in a wheel-pit, to belts, cables, and water, air and electricity under pressure, great moderation was exercised in providing for the anticipated requirements of industries to be established.

It was evident that should electric transmission of power become practicable, then much less land would be required than otherwise, because the power could be delivered to customers wherever located for use upon their own property.

PURCHASE OF LAND AT NIAGARA

The company purchased altogether 1580 acres of nearly level land, extending from its canal site above the falls, about two miles up the river along its bank, and stretching at right angles across the tracks and rights-of-way of the New York Central and Hudson River Railroad, New York, Lake Erie and Western Railroad, and Buffalo, Thousand Islands and Portland Railroad (projected) about 3½ miles to Fletcher's Corners on the Lockport Branch of the New York Central Railroad. A new residential village was contemplated in the angle of the land location, and a Junction Railway was proposed on the company's property between the trunk line railways, as shown on map on page 331.

If the Evershed plan of developments should be adopted, the company had acquired the river front and acreage required for that enterprise as described by its author. Should any other forms of power transmission be adopted, the company's real estate was most advantageously located for such purposes, and whatever land it owned in excess of that required for the power-plant would be in demand at advanced prices for purchase or lease by power customers when constructing their factories.

In carrying out the above-mentioned improvements for residence and freight transportation, two companies were formed and financed, the land company for the development of the residential tract under the title of Niagara Development Company, and the railroad transportation and terminal freight facilities under the title of Niagara Junction Railway Company. Both companies were organized in June, 1892, under the laws of the State of New York, with identical officers and directors, similar to those of The Cataract Construction Company. The financial plans were similar for both companies, with certain exceptions in amounts required because of different purposes and costs.

The capital stocks were authorized as follows:

Share Capital Authorized Par Value $100 Each	Development Company Issued Jan 1, 1899	Junction Railway Company Issued Jan 1, 1893
Common Stock to be issued in the purchase of land	$750,000	$160,000
Preferred Stock eight per cent cumulative and convertible, to be sold for cash	500,000	140,000
Land purchased from The Niagara Falls Power Company	368 acres	166 acres
at the acre price of. . . payable in common stock issue as above	$ 2,138	$ 2,500

The Niagara Falls Power Company by these transactions became the owner of all the common stocks issued, which exceeded the preferred stock and thereby acquired and held the control of both companies.

The preferred stocks were offered June 10, 1892, under Circular No. 16[1] of The Cataract Construction Company, to the syndicate subscribers under the agreement of January 17, 1890, at the rate of $2000 or two shares of preferred stocks at par, for each share of The Cataract Construction Company owned by such subscribers. The privileges of subscription were availed

[1] Further particulars of these issues of Development and Junction Railway companies will be found in Circulars Nos. 16 and 65, Appendix D, Volume I

of and $600,000 cash was provided: $480,000 for the construction of dwellings and the maintenance of the property acquired by the Niagara Development Company, and $120,000 for the acquisition of right-of-way for a small part of the railway line not derived from the power company, and for the construction, equipment and operation of a single-track standard-gauge line of the Niagara Junction Railway Company. The subscribers to the preferred stocks were nearly identical and similar to the list of "money subscribers" of January 17, 1890, who became the stockholders of The Cataract Construction Company. No commissions or allowances of any kind were made or paid to any one on account of these subscriptions.

In June, 1903, the preferred stocks of both companies were purchased at par and interest by The Niagara Falls Power Company and paid for in shares of that company at par.

By reference to the map on pages 321–322 it will be seen that the landed estate of the associated companies is located mainly within the municipal limits of the present city of Niagara Falls. About one-third is located on the river front, with projected wharfs and dock facilities, of nearly 2 miles along the navigable channel, a portion of which was deepened by the United States authorities so as to accommodate shipping from western cities upon the Great Lakes.

As the city is bounded on two sides of its location by the impassable Niagara River, its future growth must be towards the open countryside, across which, within the municipal limits, a portion of the company's lands extends for about 3½ miles at a right angle from the river. The main lines of the New York Central and the Erie railways pass for 2 miles through and by the side of the property, while the Lockport Branch of the New York Central forms the northern boundary of the estate. The New York Central station, Echota, built for the power company, is located upon this property.

For the convenience of employees the residential district was located in the central portion of the estate, and the water facilities desired by the manufacturers for shipping were provided by the company's docks, constructed at the upper end of the river front, near this central locality.

NIAGARA DEVELOPMENT COMPANY

The Niagara Development Company was organized under the business corporation law of the State of New York for the purpose of purchasing and leasing real estate and buildings and selling, leasing and improving the same. It owned in fee the residential village, christened by the Cherokee word "Echota," meaning the "Town of Refuge," and other lands in the city

of Niagara Falls, comprising 368 acres that were set apart by the power company for improvement for domestic and manufacturing purposes.

The survey of the estate was made by John Bogart, assisted by Albert H. Porter, both of the board of engineers.

The location of Echota is shown on the map at the beginning of this chapter and the development of streets and lots by the view below.

The houses were designed by Stanford White, architect of New York. The company constructed sixty-seven dwellings for the accommodation of one hundred and twelve families. A building was erected with provisions for bachelor apartments, an assembly hall, and a general store on the lower floor. The streets were paved with broken stone, the sidewalks were of concrete, and a system of drainage was installed. Potable water, sewerage and electric lights were available in each building. A plant for sewage disposal was also constructed, and a well-equipped fire department was provided in a separate house. There were 58 acres of lawn prepared, and many evergreen and Norway maple trees planted.

STREET IN ECHOTA, 1894

Echota Hall was used regularly for religious services, and by a mission Sunday school and a primary day school.

To assure larger school accommodations, an ample lot on the Echota property was donated to the board of education, upon which a modern two-story building of eight rooms was erected by the city of Niagara Falls.

The buildings were finished in natural color of shingles, with white painted trim. Under the influence of the Pan-American Exposition at Buffalo in 1901, when the period arrived for repainting the houses at Echota, a scheme[1] of color for the entire village was adopted and successfully carried out, attracting much attention from the visitors and passing railway passengers.

In the words of the New England manufacturer for whom Mr. White had previously designed and built a "workmen's settlement," the owners of Echota also concluded that "the tasty pays."

All of the structures erected by the Niagara Development Company, upon its residential property named "Echota," have been sold. The other real estate, formerly owned by the development company, is now included in the estate of The Niagara Falls Power Company by a merger with it of the property and organization of the Niagara Development Company. Edmund S. Wheeler was the first manager of the company.

NIAGARA JUNCTION RAILWAY COMPANY

The Niagara Junction Railway extends from one end of the power company's property to the other, a distance of 5.34 miles by main track, and connects with the Erie Railway and at several points with the main line of the New York Central and its Lockport branch.

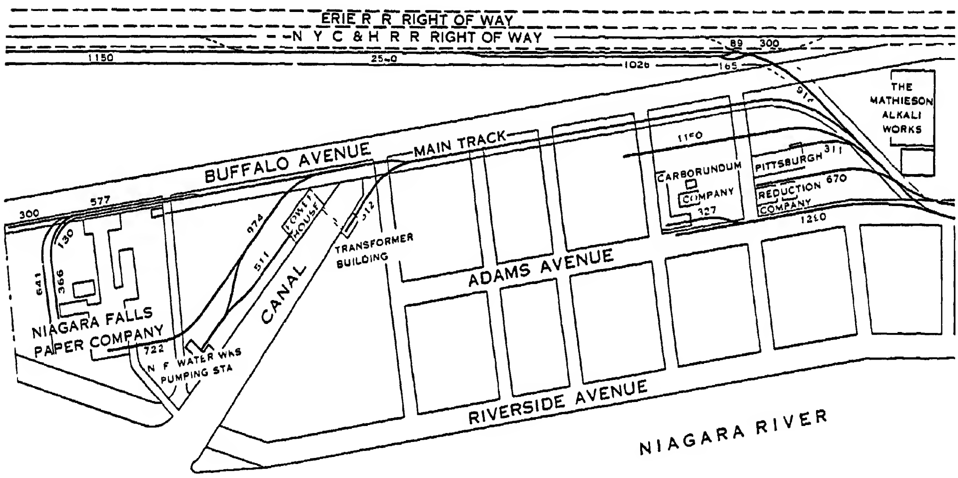
In addition to a right-of-way, 66 feet in width, for a double-track main line, with connections and sidings, the Niagara Junction Railway owns in fee 166 acres that were acquired for yard and other terminal facilities.

The line as built is of standard gauge, single track, of 80-pound rail, and with the exception of about 1000 feet is entirely within the estate of the power company.

By its main line, 5.34 miles, and sidings, 4.08 miles, June 1, 1896, to the docks of the company on the river above the falls, the Niagara Junction Railway afforded the desired facilities of transportation for an industrial community. Its right-of-way was the most convenient route for the conduit and pole line service of power, light and heat, from the power-houses to all portions of the landed estate, as well as beyond its boundaries for the lines of power transmission to Tonawanda, Buffalo and other localities.

[1] See *Architects and Builders' Magazine*, April, 1902

In anticipation of the completion of that portion of the tracks of the Niagara Junction Railway intended to furnish switching services to the new industries preparing for operation near the inlet-canal of the power company, and with a view of using electrical motor and line equipment if such an installation could be had, inquiries were made of manufacturers of electrical machinery for railway and power systems in this country for estimates including an engine or motor capable of hauling 150 tons at a speed of 10 miles an hour on grades not to exceed 15 feet in a mile. One of the leading manufacturers replied that "such an engine does not now exist, as a standard article manufactured by this or any of the other electric companies."



Map Showing Main Track and Sidings in 1896 of the Niagara Junction Railway

Two standard coal burning switching engines were purchased, the second following soon after the first, with dump and flat cars for use in filling trestles on the road with the refuse products of the factories and materials excavated in the building of the power plants.

In July, 1892, the Niagara Junction Railway Company announced its preparation to receive all freight consigned to the Niagara Falls Paper Company and to A. C. Douglass, contractor.

The original construction of the railway was under the direction of George B. Burbank, as chief engineer, and its operation was placed in charge of Edmund S. Wheeler, as general manager.

The use of steam locomotives continued until 1913 when the increase of traffic necessitated additional equipment and brought up again for consideration the relative advantages of steam and electricity.

Upon the unanimous report of the engineering staff a contract was made in February, 1913, with the Westinghouse Electric and Manufacturing Company for the replacement of the steam system by an electrical power installation of direct current at 600 volts, with locomotives, stations and a complete wire system for the switching purposes of the company. Shortly thereafter the steam locomotives were superseded by the electrical motor system which has since been continued in the operating of the greatly increased traffic of the railway.

The further evolution of the plans for the power stations and transmission system will be found in subsequent chapters in Volume Two relating to the hydraulic and the electric systems, their construction and operation.

Upon the unanimous report of the engineering staff a contract was made in February, 1913, with the Westinghouse Electric and Manufacturing Company for the replacement of the steam system by an electrical power installation of direct current at 600 volts, with locomotives, stations and a complete wire system for the switching purposes of the company. Shortly thereafter the steam locomotives were superseded by the electrical motor system which has since been continued in the operating of the greatly increased traffic of the railway.

The further evolution of the plans for the power stations and transmission system will be found in subsequent chapters in Volume Two relating to the hydraulic and the electric systems, their construction and operation.

CHARLES R. HUNTLEY
1853–1926

CHAIRMAN
BUFFALO, NIAGARA AND EASTERN POWER CORPORATION

PRESIDENT
BUFFALO GENERAL ELECTRIC COMPANY

PIONEER AND LEADER
IN THE ELECTRIC LIGHT AND POWER INDUSTRY
IN BUFFALO AND WESTERN NEW YORK

Enthusiastic, Courageous, and Persistent

A monument to his genius and foresight, to his planning and supervision, which marked a notable advance in economy and efficiency, is the great steam-plant now known as the Charles R. Huntley Station

ASSOCIATED COMPANIES FOR THE GENERATION, TRANSMISSION, AND DISTRIBUTION OF NIAGARA POWER

The power of Niagara is the keystone to the arch of Buffalo's prosperity. Electric power is the bulwark of Buffalo's industry.—Charles R. Huntley.

CHAPTER XVI

BUFFALO AWAITS NIAGARA POWER

BUFFALO in 1895, when electric service was begun by The Niagara Falls Power Company, had an estimated population of 253,000, and a total of real and personal taxables of about $130,000,000. The municipality included 39.6 square miles, with nearly 200 miles of streets.

Although Buffalo, as a rapidly growing community of manufacturers and business men, had done but little financially to assist in the utilization of the power of the Great Falls, shortly after the Gaskill-Niagara enterprise was organized, 1886, a number of the enterprising citizens of Buffalo provided a cash prize of $100,000 for a practical method of using Niagara power in Buffalo, the details of which form a part of Chapter V, this volume.

This proposal expressed a public interest in the value of Niagara power in Buffalo. While its failure to produce a method caused serious doubt of its practicability, it created a popular sentiment in favor of such use and many looked forward to its eventual achievement through a system of transmission by compressed air or water or possibly by electricity, although all these systems were then considered for long distance of doubtful efficiency and impossible commercially, because of the expense involved in distribution and application as well as in the cost of the original transmission from Niagara.

While the Niagara company had provided a large area suitable for the construction of manufactories with the intention of providing light and power therefor, the use of which must necessarily await the construction of such industrial plants, financial conditions then prevailing did not promote the construction of new factories nor the organization of new manufacturing enterprises. It was therefore considered important, for the realization of income, to provide the interest upon the capital investment made in the central power station system, to develop a plan by which Niagara power might be taken to Buffalo and distributed there for use by the many manufacturers who were favorably disposed to its adoption.

FUNDAMENTAL FACTORS ESSENTIAL TO SUCCESS

In the further survey of the problem of such transmission that was taken up actively after the first units of turbine and alternator had been successfully tested in April, 1895, there were several fundamental principles considered as essential to the financial success of such an effort, such as

(1) FRANCHISES WITHOUT EMBARRASSING CONDITIONS. The distance for transmission was about 22 miles, requiring several municipal franchises that, because of inexperience with the risks involved in high tension current lines, were likely to impose conditions that would prove difficult and expensive to comply with and possibly somewhat embarrassing technically to carry out.

(2) CONTINUITY OF SERVICE ASSURED. As a new form of power, it was evident that demonstration must be given of continuity of supply. In a district so well settled as that of Buffalo and the intervening municipalities, a failure of service, any time interrupting both light and power, would prove disappointing and expensive to the users, possibly lead to claims for damages and cause injury to the credit of the enterprise at its start. It was therefore resolved that there should be two lines of transmission and two sources of supply, that the supply of electricity from the American power-house should be supplemented by a similar supply from the Canadian side of the river, and that the lines[1] of transmission should extend from these respective power-houses on each side of the river, and be inter-connected by cables on the Suspension Bridge at the falls, and by an aerial line across the river between Fort Erie on the Canadian side, and the city of Buffalo on the American side.

(3) BLOCK SALES TO LOCAL DISTRIBUTING SYSTEMS. The management recognized from the very beginning that it was dealing with unprecedented quantities. Its large units of power were adopted with this idea, and the program for the marketing of the electricity produced was preferentially for the sale of large blocks of power, the product of one or more single turbo-electric units, and its distribution to small users through the arteries of local organizations.

(4) DEMONSTRATIONS OF UTILITY, ECONOMY AND SAFETY. In order to induce the abandonment of plants operated by the power of steam, it was necessary to demonstrate the advantages of electrical power, including its economy, its cleanliness and its dependability. While this might take some time for education, the period of preparation of the design of the line, the specifications for its motors and transformers, and the securing of all the requisite franchises from the state and the different municipalities, as well as the construction of the system, would give an opportunity for propaganda in favor of the use of

[1] For freedom of custom duties, see Appendix K, Volume II.

the power, for which provision was made by securing the services of a recognized power expert, Horatio A. Foster, whose office was established in the city of Buffalo for this purpose.

RIGHT-OF-WAY AND FRANCHISES

The applications for authority to occupy a right-of-way for power conductors were made in the name of The Niagara Falls Power Company or its assigns, and only for electric conductors for light, heat or power. The possible use of compressed air or water had been dismissed from further serious consideration by the practical demonstrations of advantages in the use of high tension alternating electric currents for long distance transmission of power and light.

The Superintendent of Public Works of the State of New York on August 30, 1895, granted the Niagara company permission to construct and maintain electric conductors for light, heat or power, along, upon and across the public lands and waters, property of the state, in the manner and at the places on the "State Ditch" and on Tonawanda and Ellicott creeks in Erie County, in accordance with a map filed in his office. The conditions of this permit were not considered unreasonable regulations.

Supplemental permits were issued by the Superintendent of Public Works upon application by The Niagara Falls Power Company, by which it was authorized to place its electric conductors upon Erie Canal lands in the counties of Erie and Niagara, in conduits or subways under the surface of the towing path or the berm-bank of the canal, also under the bed of the canal whenever necessary to cross. This was in addition to the original permit for transmission lines on poles.

The state reserved the right to place in such conduits or subways telephone lines for the purpose of communication between the several canal section superintendents and their employees.

The petition of The Niagara Falls Power Company to the Common Council of the city of Buffalo for a franchise authorizing the distribution of electricity within the said city was presented on October 15, 1894. This action formally opened the public discussion of the advantages of electrical power. Communications from citizens appeared in the daily papers, some correspondents finding the prospect of Niagara power in Buffalo an assurance of increase of property values and the growth of the city as an influential business center, while others expressed apprehension as to the use of the alternating current, the dangers of high voltages, and the lack of experience in its use as a means of power where many employees were engaged. Some parties thought the company should pay for the privilege of introducing its power, and a royalty or tax to the city on the revenue obtained therefrom. Public hearings

were held, one particularly for the purpose of introducing the representatives of the manufacturers of electrical machinery, who were requested to state on behalf of their companies what devices they had perfected for commercial use in the transforming of high voltage and the means of its application to machinery already engaged in the industrial arts.

There were numerous hearings before the Common Council of the city, reports of various committees appointed to examine into the subject, and discussions by experts, some advocating the use only of continuous current and others that of the alternating current, while the question of measurement of the current used and the terms to be charged therefor were subjects of frequent comment by the press and formed a part of the daily converse of the citizens.

In compliance with a suggestion made at a meeting of the Common Council Committee, February 7, 1895, that the city purchase the power from the company at Niagara and request a proposal that would give municipal ownership and control of 10,000 or more horse-power, The Niagara Falls Power Company made the following offers to the city of Buffalo:

The company is now ready to execute a contract in either one of three forms for the sale to the city of Buffalo of 10,000 horse-power, deliverable on the lands of the company at Niagara, upon the following terms and at the following prices

10,000 horse-power undeveloped on lands of the company at Niagara, at $10 per horse-power per annum, twenty-four-hour power, the city of Buffalo to make its own wheel-pits and side tunnels and to put in its own wheels. The necessary water, the inlets and the necessary discharge space in the completed tunnel of the company are now ready to produce this power

This form of contract is of public record at Lockport with The Niagara Falls Paper Company, by whom this form of power has been in satisfactory use for over one year, showing that interruptions from ice or other causes are not to be feared, or

10,000 horse-power developed on the shaft of turbines furnished by the company on the company's lands at Niagara, at $13 per horse-power per annum, twenty-four-hour power, so to be delivered within six months from the execution of the contract, or

10,000 horse-power electrical, alternating current, at a voltage of 2000 as it comes from the company's generators at the power-house, twenty-four-hour power, at $18 per horse-power per annum, to be delivered within eight months from the execution of the contract.

In the event of the city making a contract for power, in either of the above forms, the company will place at the disposal of the city all the data which it has gathered in a five-years' study of the problems of transmission, and will arrange for a satisfactory use by the city of the rights-of-way between Niagara Falls and Buffalo which the company has acquired. These rights-of-way are three in number and are practically complete.

The company cannot name a price for electrical power transmitted to the Buffalo city line, as in the question of transmission are involved the uncertainties of the losses and cost of operation and maintenance. . . .

If the city does not desire to purchase power at Niagara as above suggested, then, within the limits and to the extent above stated, but not otherwise, The Niagara Falls Power Company respectfully renews its application for a franchise in the city of Buffalo.

Municipal ownership became a topic of active discussion among the citizens. The financial requirements of such relations to Niagara power as those proposed were soon understood to be impracticable, and the negotiations were resumed for a franchise for the introduction and distribution of electric energy by The Niagara Falls Power Company within the municipal limits. No definite results, however, were attained until the close of the year 1895.

The following is a record of the company's efforts to obtain favorable action by the city of Buffalo from October 15, 1894 to June 30, 1897:

1894

October 15 — Petition of The Niagara Falls Power Company to the Common Council of the city of Buffalo for franchise, authorizing the distribution of electricity within said city. Filed in the City Clerk's Office, Oct. 22, 1894, and referred.

1895

December 2 — Franchises of the city of Buffalo to several companies for the introduction of electrical power within the city were adopted by the Common Council. Tax of 2½ per cent on gross receipts after six years. Franchise for thirty-six years

December 16 — Approval by mayor of power franchise adopted by Common Council, December 2, 1895.

1896

January 14 — Resolution of board of directors of The Niagara Falls Power Company, accepting grant by the city of Buffalo for the introduction of electrical power within the city.

June 18 — Certificate of Incorporation of the Cataract Power and Conduit Company filed in Erie County Clerk's Office.

June 22 — Plans and specifications, submitted by The Niagara Falls Power Company, having been approved by the Board of Public Works, the Common Council granted the Cataract Power and Conduit Company permission to lay conduits.

June 24 — The Niagara Falls Power Company made an assignment of its Buffalo franchise to the Cataract Power and Conduit Company that was accepted by Conduit Company.

July 13	Assignment of Buffalo franchise by The Niagara Falls Power Company and its acceptance by the Cataract Power and Conduit Company took effect as of this date, by resolution of the Common Council passed October 5, 1896, concurred in by the board of councilmen, October 7, 1896.
November 15	Power transmission to Buffalo inaugurated.

1897

June 30	Resolution of Common Council of the city of Buffalo, adopting the report of the Street Committee amending the franchise.

This is a partial record of strenuous efforts for about two years on the part of those who were associated with the Niagara enterprise and held responsible positions in the manufacturing community of Buffalo, and who, while desirous of reducing the cost of the power that they used, had yet to be convinced of the safety and economy of electric power, particularly in alternating currents, by a careful study of its characteristics for which there was no precedent to inspire their confidence or to direct their methods.

Franchises from the Tonawanda municipality were obtained by The Niagara Falls Power Company in 1898 and assigned to the Tonawanda Cataract Power Company organized in 1899 therefor, with a capital of $100,000 of which 60 per cent was owned by the Niagara company. The first board of directors was composed of Edward D. Adams, Francis Lynde Stetson, Edward A. Wickes and William B. Rankine (La Partie Carrée) and Charles A. Sweet, Lincoln A. Groat of Buffalo, and De Lancey Rankine of Niagara Falls.

The Tonawanda Lighting and Power Company, the local organization supplying direct-current light, was merged with the new company, under the name of the Tonawanda Power Company, and its entire capital stock was acquired by The Niagara Falls Power Company. On June 1, 1917, these shares were sold to local interests in the Tonawandas at $175 per share, thereby increasing the assets of The Niagara Falls Power Company by $437,500 cash.

ORGANIZATION OF CATARACT POWER AND CONDUIT COMPANY

The insurance statistics indicated that there were about 400 steam boilers in active use in Buffalo at that period, having a total rating of more than 33,500 effective horse-power. The fact that steam-coal in Buffalo was then, as for some years, selling in large quantities at a price not much exceeding $2 per ton, gave a basis upon which to estimate at what price electric power and light must be available in Buffalo in order to meet the competition resulting from the use of coal upon the conditions named. Fortunately the largest consumers

of light and power in Buffalo were the International Railroad Company and the Buffalo General Electric Company that were under a personal management familiar with the problems connected with the production of power. Those conducting the electric light company were naturally interested in the announcement of the Niagara company's intention to extend its line to Buffalo, and were quite willing to consider the subject of co-operation when it

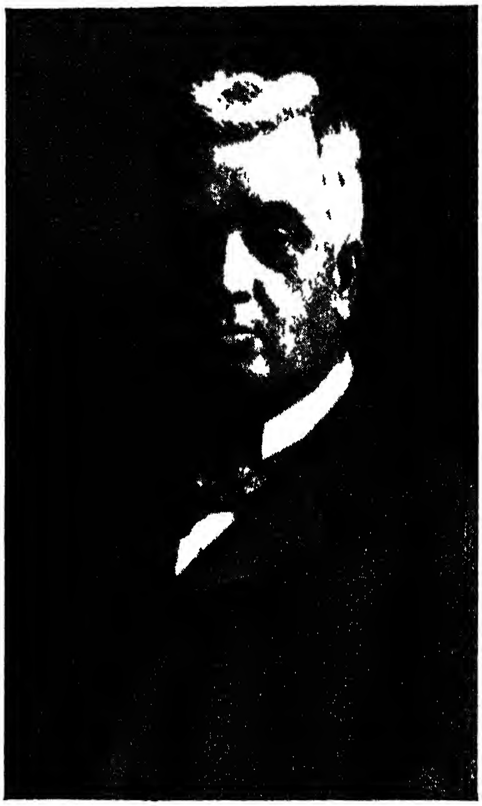
DANIEL O'DAY
1844–1906
DIRECTOR
CATARACT POWER AND CONDUIT COMPANY

was suggested that the Niagara company desired only to bring its power to a station at the outskirts of Buffalo where it was willing to sell the same at a wholesale price to a distributing company.

As a company which had established the largest of units as expressed in water resources and mechanical and electrical devices for the development of power, The Niagara Falls Power Company was a producer *en gros* that desired a distributer *en détail*. Effective co-operation in distribution required local representation by citizens of influence.

It was seen that the financial structure of the distributing organization should start with the credit of The Niagara Falls Power Company, to which it would invite the association of influential and successful local interests.

It was finally concluded that the best way to create a mutuality of interest, as one of the essential details of success in such a venture, was to organize an intermediate company for operation in Buffalo and to obtain through subscriptions to its securities the co-operation of some of its most enterprising and



George Urban, Jr.
Incorporator and Presidfnt
Cataract Powfr and Conduit Company

influential citizens interested in the establishment of Niagara electrical power in the municipality of Buffalo. This was accomplished by the organization of the Cataract Power and Conduit Company, with the allotment of subscriptions to about one half its capital stock to the associates selected for that purpose among citizens of Buffalo.

The Cataract Power and Conduit Company was incorporated under the Transportation Corporation Law of the State of New York, June 17, 1896,

by William B. Rankine, George Urban, Jr., and Charles R. Huntley, for the period of fifty years, with an authorized capital stock of $2,000,000 divided into 20,000 shares of a par value of $100 each. There was an authorized issue of $2,000,000 in five per cent bonds, which were sold as funds were required for construction.

The first board of directors was constituted as follows:

Daniel O'Day	Buffalo	Francis Lynde Stetson	New York City
George Urban, Jr.	Buffalo	Edward A. Wickes	New York City
Charles R. Huntley	Buffalo	William B. Rankine	New York City
Edward D. Adams	New York City	Darius O. Mills	New York City
John Jacob Astor	New York City		

The executive officers were:

EXECUTIVE COMMITTEE

Daniel O'Day — John Jacob Astor
George Urban, Jr. — Edward A Wickes
William B. Rankine

OFFICERS

President:	George Urban, Jr.
Vice-president and General Manager	Charles R Huntley
Secretary and Treasurer	William B. Rankine

The objects of the organization were stated to be

> the use and distribution of electricity for light, heat or power within the city of Buffalo, the construction of conduits, poles, pipes or other fixtures in, on, over and under the streets, alleys, avenues, public parks, and places within the city of Buffalo for the conduct of wires and pipes and for conducting and distributing electricity or pneumatic or other power or energy produced by the agency of electricity or otherwise, the making, selling, or leasing of machines, instruments, apparatus and other equipments for the distribution, delivery or practical application of electric or pneumatic or other energy, and such other business as shall be naturally incident thereto or connected therewith.

It was also provided that no evidence of debt, to be secured by a mortgage or other lien upon the property of the company, should be issued without the consent of the holders of three-fourths of the capital stock; also that no stockholder should be entitled to vote at any meeting for more than two-thirds of the number of directors to be elected at such meeting.

The subscribers to the capital of the company as required for its construction, included the following residents of Buffalo and its vicinity:

H. B. Alverson	Darius O. Mills
A. D. Bissell	Daniel O'Day
Dann & Robinson	Robert W. Pomeroy
William P. Humbert	De Lancey Rankine
Francis R. Hunsicker	Charles A. Sweet
Charles R. Huntley	George H. Teller
Franklin D. Locke	George Urban, Jr.

PROPOSALS FOR TRANSMISSION LINE

The transmission of power, as electricity at a high voltage over wires, strung on wooden poles extending from Niagara to Buffalo, constituted a serious problem to various interests, besides those represented by The Cataract Construction Company.

The state authorities desired to assist such a project, however novel, but in the absence of precedents they necessarily relied upon the well-known character and responsibility of the applicants, and the watchfulness of their representatives during progress of the work under a general permit, ready to impose regulations should it seem desirable in the protection of citizens and their property, whether they were to become beneficiaries of the scheme or not.

The applicants found it necessary to apply many times for additional privileges and powers, as experiences were gathered in acquiring the right-of-way, by purchase, by lease, and by local permits to cross roads, canals, railways, etc. The franchises were mainly such as would be required for an extension of a public utility intended for general service in the interest of economy and convenience in manufacturing and domestic activities.

Again, as a pioneer, The Cataract Construction Company had to find a way to overcome unknown difficulties that arose and obstructed its progress

Public interest was expressed by its curiosity. Niagara power was as much needed en route at Tonawanda for instance, as in Buffalo to increase property values and population. Would it be safe and sure? Could it be relied upon, day and night, without interruption? And many other queries accompanied the declaration that "anyway, we will wait for Buffalo to act first."

Proposals were received from the General Electric and Westinghouse Electric companies, which were in all essential respects alike. Each company proposed a project for the transmission of 10,000 horse-power from the bus-bars of the Niagara power-house to the sub-station at Buffalo, transforming the two-phase currents generated at the power-house into three-phase currents at 11,000 or 22,000 volts by step-up transformers.

The General Electric Company designed a single pole line with two circuits, and suggested, if desired, a second pole line with a spare circuit. The Westinghouse Company proposed to use two lines of steel poles, each to carry one circuit.

INCREASING USE OF NIAGARA POWER IN BUFFALO

Upon completion of its terminal house at the city line the Cataract Power and Conduit Company began the supply of Niagara power in Buffalo on November 15, 1896. The initial use was to the extent of approximately 1000 horse-power for the operation of street railways.

An important dinner was given on January 12, 1897, at the new Ellicott Club in Buffalo, to commemorate the introduction of Niagara power into the city of Buffalo, by the parties interested in promoting the introduction of this power, at which various scientists were present and explained the latest development in the electrical science and the facilities which were thereby afforded for the transmission of power, so that it could compete with the already established steam plants which electrical machinery was designed to replace.

There were about 400 guests present, including many recognized leaders among engineers, inventors, manufacturers and capitalists. The toasts and speakers were

The Company	Francis Lynde Stetson, of New York, the toastmaster of the evening
Welcome to Buffalo	His Honor Mayor Jewett
The Empire State	Controller J. A. Roberts of Albany
Electricity	Nikola Tesla, of New York
The City of Buffalo	Charles W. Goodyear, of Buffalo
Water-power	Charles A. Pillsbury, of Minneapolis

The *New York Tribune* reported that the general trend of the speeches was admiration of the achievement, which it was said might justly be regarded as one of the triumphs of the century, and prophecies of the great future awaiting the Niagara frontier when the electric power reaches its fullest development.

The growth of confidence notwithstanding the continuity and other advantages of the service was slow. The education of the manufacturers as to the actual cost of their steam-power continued. Both curiosity and interest prompted investigations of conduits, transformers and motors. Each new motor installation was visited, experiences gathered and exchanged, and estimates made of the cost of changing from steam to electricity. The services of Horatio A. Foster, a mechanical and electrical engineer, were always available

for guidance in such studies, he having been stationed in Buffalo since 1897 as the representative of The Niagara Falls Power Company for such purpose.

There were many vexatious delays in extending the lines of transmission of the Cataract Power and Conduit Company in the streets of the city of Buffalo and in making installations for the customers' use of the electric current. The net income earned from the sale of electricity was disappointing during the first years of its operation. There was, however, a steady increase of customers, and after 1900 the growth of the business of the company was rapid. It was constantly urged to extend its lines of transmission for new customers who awaited their opportunity to adopt the new power. During the ten-year period from June, 1897, the company issued and disposed of an average of about $85,000 bonds per annum for the extension of its system of distribution in Buffalo, with the result that in 1906 the first mortgage five per cent bonds to the amount of $1,000,000 had been issued and sold. As the productive property was extended and more capital was invested, the customers multiplied and the credit and popularity of the organization increased.

The rapid development of the use of electric power in Buffalo obliged the Cataract Power and Conduit Company, when it ascertained that no additional current could be obtained from The Niagara Falls Power Company for some time, to contract with the Electrical Development Company of Ontario for 5000 horse-power to be delivered at the transformer-station of the Canadian Niagara Power Company for transformation and transmission on its wires to the Cataract Power and Conduit Company at Buffalo, where it was greatly needed.

It has been stated that during the entire period of Cataract Power and Conduit Company's activities in distributing Niagara power, it had never lost a customer on account of dissatisfaction with its rates or service.

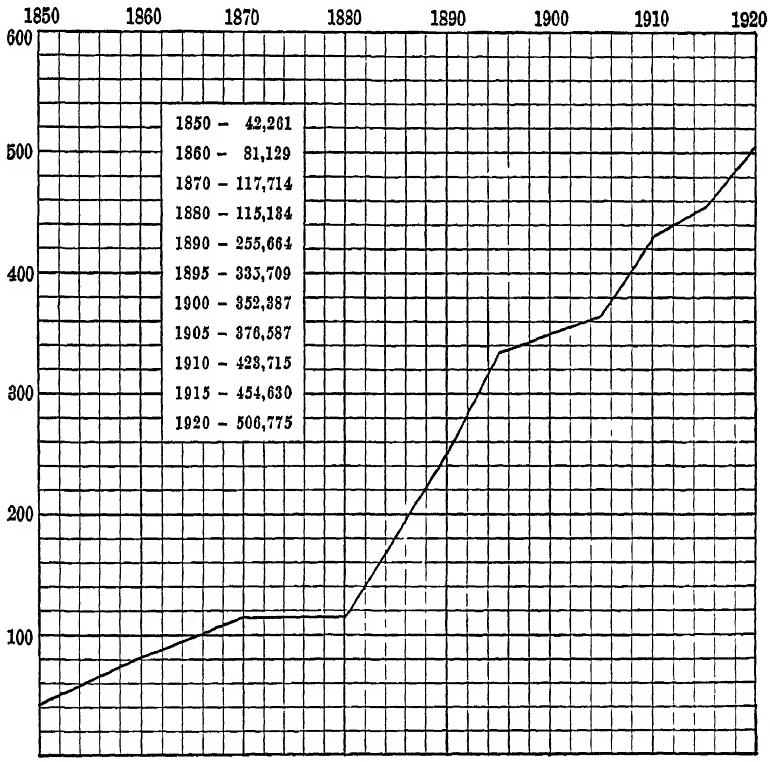
The following charts show the record of growth in population and assessed valuation of property in the city of Buffalo from the organization of The Cataract Construction Company in 1886 through the consolidation of the Cataract Power and Conduit Company, and the Buffalo General Electric Company, under the title of the latter in 1915.

BUFFALO GENERAL ELECTRIC COMPANY PURCHASES CATARACT POWER AND CONDUIT COMPANY

By agreement of December 18, 1913, that became effective July, 1915, the Buffalo General Electric Company purchased from The Niagara Falls Power Company its entire holdings, 10,050 shares, of the capital stock of the Cataract Power and Conduit Company, at the price of $141 per share, payable in $1,005,000 of the first refunding five per cent gold bonds, due 1939,

of the Buffalo General Electric Company at par, and the balance in cash, together with interest thereon at the rate of six per cent per annum from December 1, 1913, to the date of the completion of the sale.

The Public Service Commission of New York, Second District, by its order of June 24, 1915, had approved of this transaction and consented to the acquisition by the Buffalo General Electric Company of *all* the outstanding shares of the Cataract Power and Conduit Company, the merger of the two



Population in Thousands, City of Buffalo

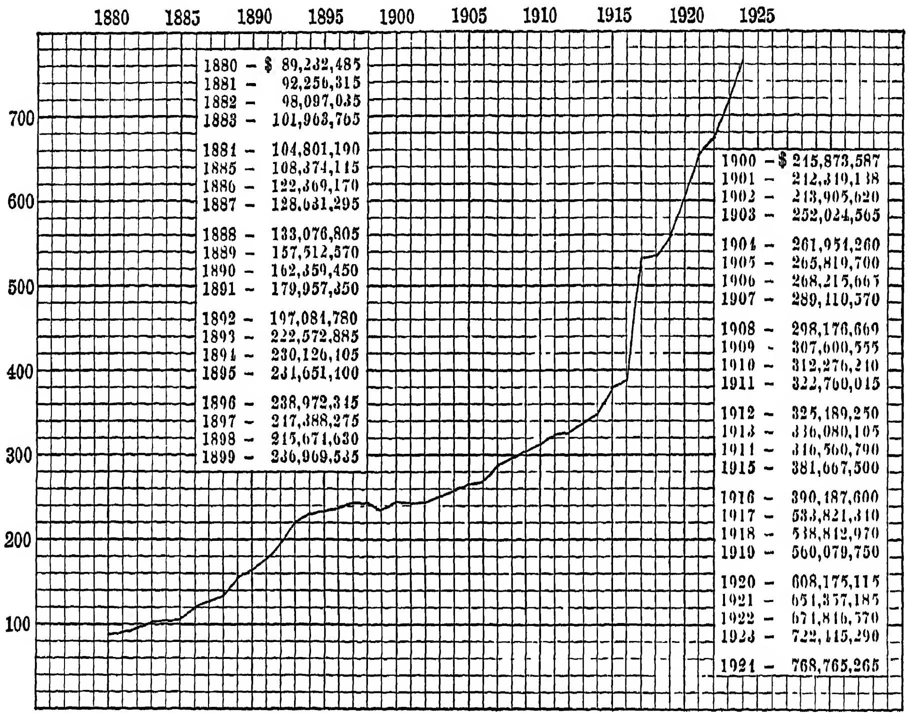
companies, and the operation of the combined properties under the franchise of the Buffalo General Electric Company.

In September, following the receipt of the bonds, they were sold *en bloc* at the price of 95 per cent and accrued interest cash, and the proceeds $1,418,500 were added to the resources of The Niagara Falls Power Company.

[1] The abrupt rise in the population line as charted from 1880 to 1890, should not be taken to indicate that the marked increase in population began with 1880 The increase began actually about 1886 with the plans for power utilization. The line is drawn from the point indicating the taking of the 1880 census to the point indicating the taking of the 1890 census, and growth is therefore averaged and diagramed by decades, not by years.

ELECTRIC COMPANY ASSUMES MAJOR POSITION AT BUFFALO

The Buffalo General Electric Company, by its absorption in 1893 of the three local companies,[1] and by its purchase in 1915 of the Cataract Power and Conduit Company that brought Niagara power to Buffalo in 1896, acquired a major position in the electrical field of Buffalo, and by wise and liberal management became a successful institution, of which the citizens of Buffalo may well be proud.



Assessed Valuation in Millions of Dollars, City of Buffalo

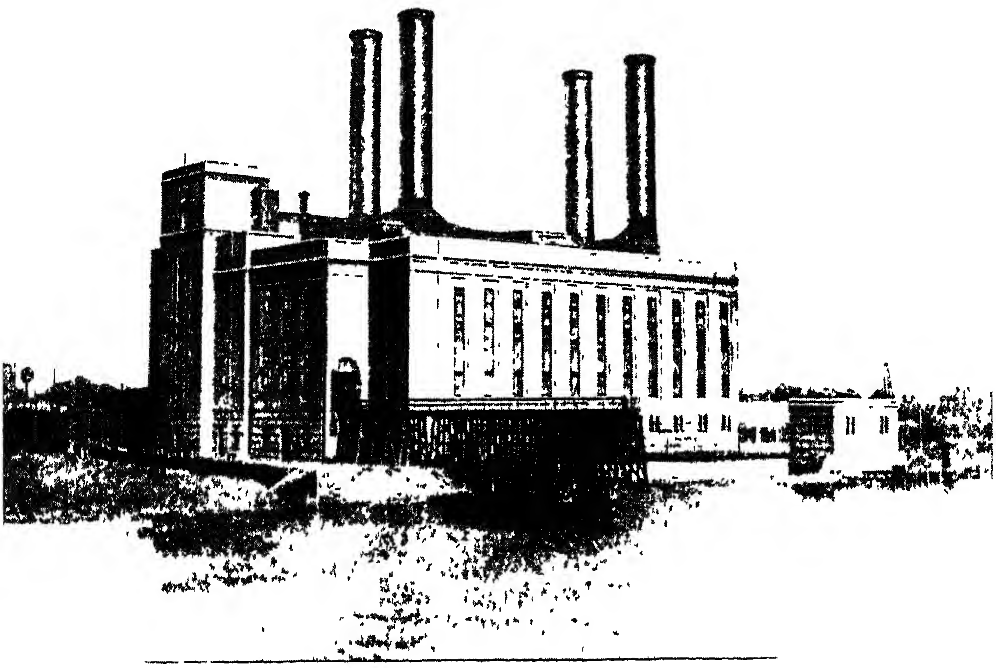
In 1923–1924 practically 90 per cent of all the industrial plants in Buffalo were fully electrified.

President Huntley declared, "We are the link in the chain between the producer of Niagara power and the consumer of power."

In its strength and in conformity with its business policy, the company voluntarily and successively reduced its rates for electric current furnished its customers, thereby, in each case, adding to its popularity and increasing its business profits.

[1] U S Electric Light and Power Company, Brush Electric Light Company, Thomson-Houston Electric Light and Power Company.

In the foresight of its management it favored the erection of a large addition to its steam-electric river station to fully protect its customers in emergencies and to provide for its ever-increasing demand. This station, with an addition (which will bring the total capacity to 200,000 horse-power) almost complete, is now a part of the Buffalo, Niagara and Eastern Power Corporation equipment. It has been christened by resolution[1] of the board of directors of the



THE CHARLES R. HUNTLEY STATION, EXTERIOR

Buffalo, Niagara and Eastern Power Corporation of October, 1926, "The Charles R. Huntley Station" in honor of the late president.[2]

ORGANIZATION OF BUFFALO, NIAGARA AND EASTERN POWER CORPORATION

On May 14, 1925, the Buffalo, Niagara and Eastern Power Corporation was chartered under the laws of the State of New York for the purpose, among others, of acquiring control of the properties of Buffalo General

[1] Appendix G, Volume I.

[2] See portrait and text on page 334.

Electric Company, The Niagara Falls Power Company, Tonawanda Power Company, and Niagara, Lockport and Ontario Power Company, through ownership of their common capital stock, and received permission from the Public Service Commission to hold all or any part of the common capital stock of each of the said four named companies.

Pursuant to permission granted by the Public Service Commission, Buffalo, Niagara and Eastern Power Corporation issued its cumulative preferred stock of the par value of $25 per share, entitled to receive dividends at the rate of $1.60 per annum per share, and its common stock, without par value, in exchange for the issued common capital stock of the four named companies.

More than 99 per cent of the total issued common capital stocks of the four named companies has been exchanged. The stockholders of the Buffalo, Niagara and Eastern Power Corporation and subsidiaries number approximately 20,000, and the vast majority are residents of the territory served.

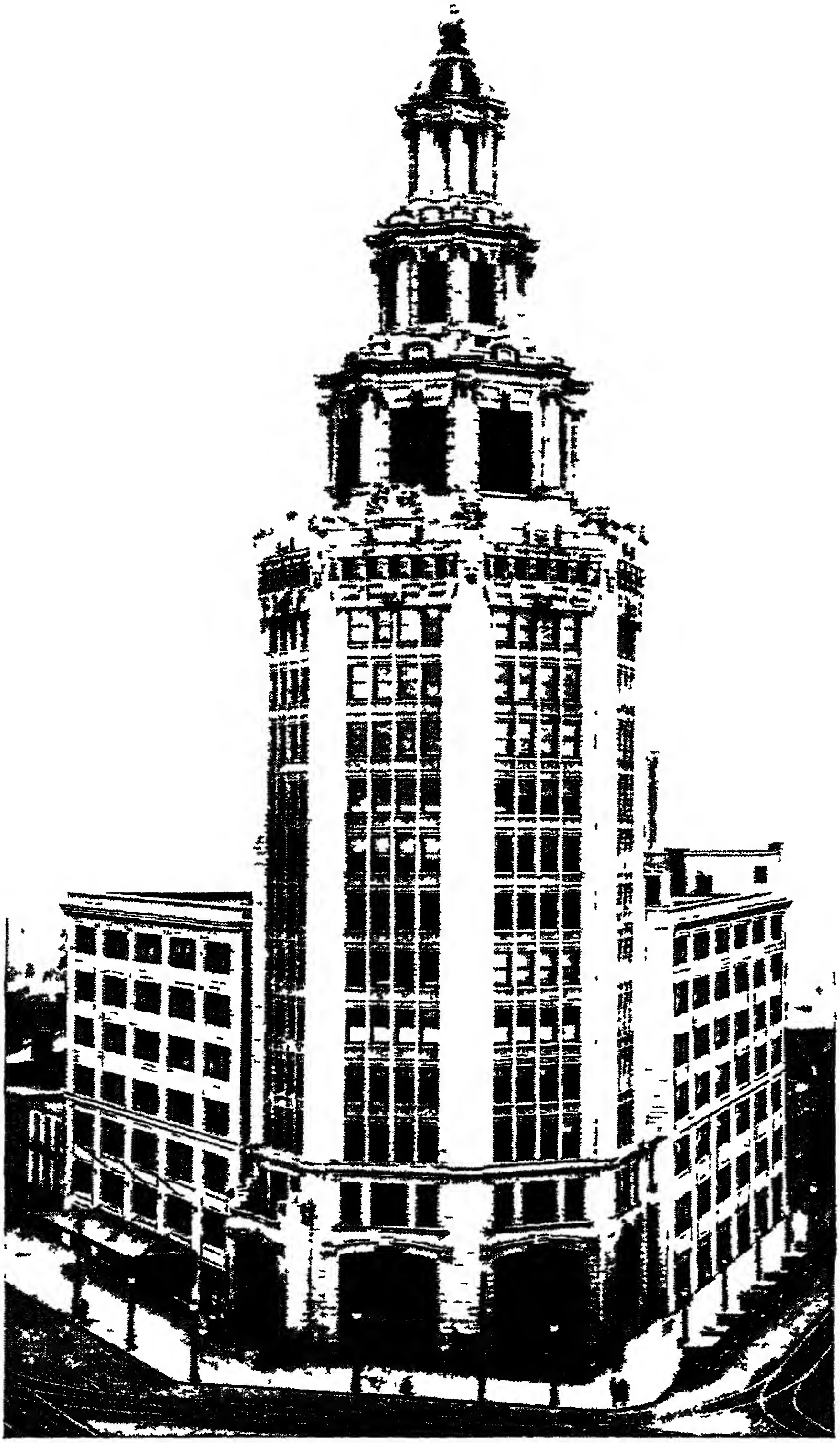
As a matter of economics, the linking together of power-producing plants and the interconnecting of neighboring distributing systems into a one-unit service organization is most desirable. These four companies acquired, all operating in western New York State, had a community of interest. The grouping of their properties under a unified management results in a centralized policy and a co-ordinated system of production and distribution.

Hydro-electric power production at Niagara Falls necessarily must be continuous if the maximum use is to be made of the limited volume of water now permitted by treaty to be diverted around the falls for power purposes. The use of power by consuming industries and by communities continually varies in peak requirements. By linking the Niagara power-plants with smaller hydro-electric power-plants in the central part of New York State, and also with steam-electric power-plants, there is provided through a single control the greatest possible flexibility in the shifting of power whenever and wherever needed. This is sound business and economic good sense.

SUMMARY FROM REPORT OF BUFFALO, NIAGARA AND EASTERN POWER CORPORATION

The following abridged histories of the companies controlled by the Buffalo, Niagara and Eastern Power Corporation, with short descriptions of their properties are taken from the first report of the stockholders of the company, March 1, 1926.

Buffalo General Electric Company: Incorporated under the laws of New York, August 1, 1892, as a consolidation of the Brush Electric Light Company and the Thomson-Houston Electric Light and Power Company, which



THE "ELECTRIC BUILDING" AT BUFFALO

EXECUTIVE OFFICES, BUFFALO, NEW YORK
BUFFALO GENERAL ELECTRIC COMPANY
BUFFALO, NIAGARA AND EASTERN POWER CORPORATION
NIAGARA, LOCKPORT AND ONTARIO
POWER COMPANY
AND OTHER ALLIED COMPANIES

latter company had previously absorbed the United States Electric Light and Power Company. On September 1, 1915, merged the Cataract Power and Conduit Company. It does the entire electric lighting and power business of Buffalo, and also supplies Lackawanna, West Seneca, Blasdell, Cheektowaga, Amherst, Williamsville, and Kenmore, and owns the entire capital stock of the Niagara Electric Service Corporation, supplying Niagara Falls, New York. Population served, 600,000. Steam-electric power-plant equipped with three 20,000 kilowatt and one 35,000 kilowatt units, and a new 60,000 kilowatt unit under construction. Energy also purchased from The Niagara Falls Power Company.

The Niagara Falls Power Company: Incorporated under the laws of New York, October 31, 1918, as a consolidation of The Niagara Falls Power Company (old company), Hydraulic Power Company of Niagara Falls, and Cliff Electrical Distributing Company. The consolidation was made under the terms of an agreement between the three corporations dated September 20, 1918. Owns and operates hydro-electric generating plants in Niagara Falls, New York, and Niagara Falls, Ontario. The system has an aggregate generating installation of 680,000 horse-power. Present restrictions on the use of water from the Niagara River limit the output of the system plants to about 500,000 horse-power. Owns approximately 1350 acres of land in and adjacent to Niagara Falls, New York, devoted to sites for factories, transmission lines and switching structures. Acquired Niagara Gorge Railroad Company (1925), including its right-of-way at the river's edge through the Niagara Gorge, its riparian rights and franchises. Owns all the stock of the Niagara Junction Railway Company. Also owns all of the capital stock (except directors' qualifying shares) and all of the funded obligations of the Canadian Niagara Power Company, Limited.

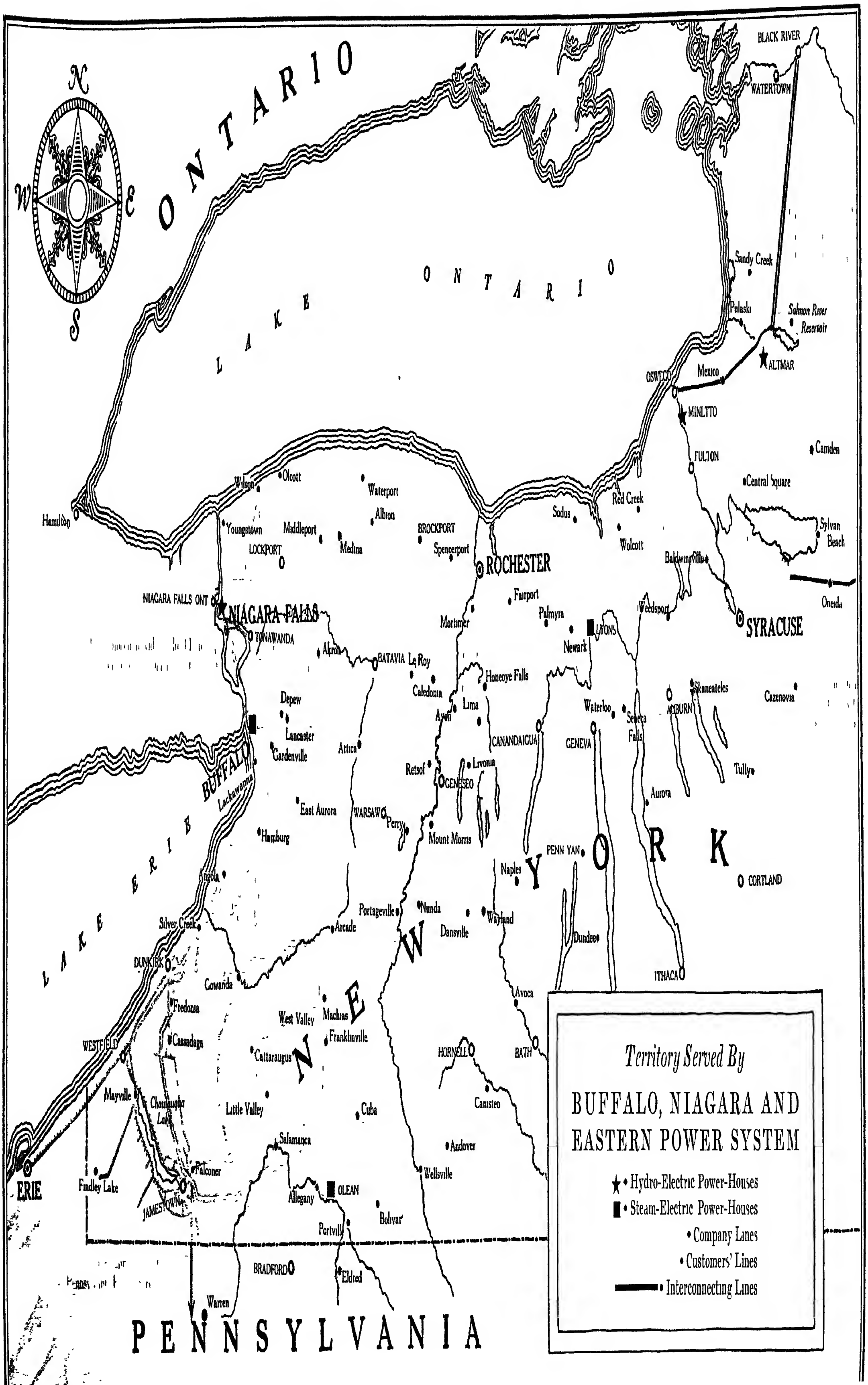
Tonawanda Power Company: Incorporated under the laws of New York, March 21, 1899, as a consolidation of the Tonawanda Lighting and Power Company and the Tonawanda Cataract Power Company. Purchases electric power from The Niagara Falls Power Company for distribution in North Tonawanda, Tonawanda and adjacent sections, serving a population of about 40,000, and operating under perpetual franchises. Controls and owns all capital stock of the La Salle Electric Corporation and the Grand Island Light and Power Corporation, serving La Salle, and Grand Island, respectively.

Niagara, Lockport and Ontario Power Company: Incorporated May 20, 1894, to engage in the production and distribution of electric power in western and central New York State. Owns and operates (*a*) hydro-electric plant on the Salmon River northeast of Syracuse of 35,000 horse-power capacity; (*b*)

a steam-electric generating plant at Lyons, New York, of 40,000 horse-power capacity; leases a hydro-electric plant on the Oswego River at Minetto, New York, of 12,000 horse-power capacity, and purchases from The Niagara Falls Power Company and the Ontario Power Company (Canadian), under long term contracts, 130,000 hydro-electric horse-power. Distributing system is interconnected with the generating plants of The Niagara Falls Power Company and of the Hydro-Electric Power Commission of Ontario at Niagara Falls. It is also interconnected with the Buffalo General Electric Company system at Buffalo. The lines of the Niagara, Lockport and Ontario Power Company are also connected up for emergency service and for the interchange of surplus power with the following systems in contiguous territory: (*a*) Northern New York Utilities, Incorporated, which owns and operates hydro-electric and steam-electric generating plants and supplies electric service to cities, towns and villages in several counties in northern New York State; (*b*) Adirondack Power and Light Corporation which owns and operates hydro-electric and steam-electric generating plants and serves cities, towns and villages in central and eastern New York State; and (*c*) Penn Public Service System operating hydro-electric and steam-electric plants and rendering electric service in the states of Pennsylvania and Maryland. The generating capacity of the various power sources interconnected through the Niagara, Lockport and Ontario Power Company's transmission system aggregates more than 2,000,000 horse-power.

The territory reached, and served in whole or in part, by the Niagara, Lockport and Ontario Power Company embraces seventeen counties in New York State and two in Pennsylvania with a population in excess of two million people. The company holds franchises in more than two hundred cities, villages and towns. Electric power is sold at wholesale to other public utility companies and to municipalities, to electrically-operated railways, and retailed for manufacturing, commercial and domestic service.

The following electric utility companies have been acquired and merged with the Niagara, Lockport and Ontario Power Company: Salmon River Power Company (1918), operated in Oswego, Onondaga and Wayne counties; Niagara and Erie Power Company (1922), operated in Erie and Chautauqua counties; Western New York Electric Company (1925), operated in Chautauqua County; Olean Electric Light and Power Company (1925), operated in Cattaraugus and Allegany counties; Livingston-Niagara Power Company, operated in Livingston and Monroe counties; Bryant Power Company, Incorporated, and Cambria Power Company, Incorporated, both operated in Niagara County; Seneca Transmission Company, Incorporated,



N
S
E
W
ONTARIO
LAKE ONTARIO
BLACK RIVER
WATERTOWN
Sandy Creek
Pulaski
Salmon River Reservoir
ALTMAR
Mexico
OSWEGO
MINLTTO
FULTON
Camden
Central Square
Sylvan Beach
Oneida
Baldwinsville
SYRACUSE
Red Creek
Sodus
Wolcott
Weedsport
Hamilton
Wilson
Olcott
Waterport
Albion
Youngstown
Middleport
Medina
BROCKPORT
Spencerport
LOCKPORT
ROCHESTER
Fairport
Palmyra
LYONS
Newark
NIAGARA FALLS ONT
NIAGARA FALLS
TONAWANDA
Akron
BATAVIA
Le Roy
Caledonia
Mortimer
Honeoye Falls
Lima
Avon
Depew
Lancaster
Gardenville
Attica
Retsof
GENESEO
Livonia
CANANDAIGUA
GENEVA
Waterloo
Seneca Falls
AUBURN
Skaneateles
Cazenovia
Tully
Aurora
BUFFALO
Lackawanna
East Aurora
WARSAW
Perry
Mount Morris
Hamburg
LAKE ERIE
Angola
NEW YORK
PENN YAN
Naples
CORTLAND
Silver Creek
Portageville
Nunda
Wayland
Arcade
Dansville
Dundee
DUNKIRK
Cowanda
ITHACA
Fredonia
Avoca
West Valley
Machias
Franklinville
Cassadaga
WESTFIELD
Cattaraugus
HORNELL
BATH
Mayville
Chautauqua Lake
Little Valley
Cuba
Canisteo
Salamanca
Andover
Falconer
ERIE
Findley Lake
JAMESTOWN
Allegany
OLEAN
Wellsville
Bolivar
Portville
BRADFORD
Eldred
Warren
PENNSYLVANIA
Territory Served By
BUFFALO, NIAGARA AND EASTERN POWER SYSTEM
Hydro-Electric Power-Houses
Steam-Electric Power-Houses
Company Lines
Customers' Lines
Interconnecting Lines

operated in Erie County; Bradford Electric Company, operated in McKean County, Pennsylvania; and the Warren and Jamestown Street Railway, operated between Warren, Pennsylvania, and Jamestown, New York.

Power Plants: The combined physical properties include electric generating stations with a total installed capacity of 725,000 kilowatts, of which 545,000 kilowatts is hydro and 180,000 kilowatts is steam. This includes the 60,000 kilowatt unit now being installed in the River Station of the Buffalo General Electric Company and which was put into service during the fall of 1926. Limitations in the use of water for power development at Niagara Falls reduce the operating capacity of the hydro-electric plants to approximately 80 per cent of their installed capacity.

While there were no major construction projects in work during 1925 in connection with the hydro-electric generating plants at Niagara Falls, Niagara Station No. 3-C, containing the three 70,000 horse-power units which were put into commercial operation during 1924, was fully completed, and official tests of these units were made for the Niagara Control Board. These tests indicated a turbine efficiency of 93.8 per cent and a combined efficiency of turbine and generator of 92 per cent. These efficiencies in the conversion of the energy of falling water into electrical energy are higher than previously have been attained in any hydro-electric power developments.

The Niagara generating plants were operated at capacity throughout the year, within the limits of the governmental restrictions in the use of water. The kilowatt hour output for the Niagara system reached a new high level for the year with the stupendous total of 3,161,130,010, an increase of more than 10 per cent over the previous year, and 50 per cent above the output for 1918, the year in which the present Niagara system first operated as a unit. This output approximates one-third the total kilowatt hours of electricity sold by central stations in the entire State of New York. To have produced this same amount of electric service through the use of coal in steam-electric generating plants would have required about three-and-one-half million tons of fuel.

Transmission Lines: The high-tension transmission system of the Niagara, Lockport and Ontario Power Company weaves a network of lines over the western and central part of New York State. It embraces 656 miles of lines on steel towers and 788 miles of lines on wooden poles. There are 948 miles of transmission circuits insulated for 110,000 volts, 200 miles insulated for 60,000 volts, and 693 miles insulated for from 4000 volts to 60,000 volts. Right-of-way owned in fee, 376 miles; permanent easement for right-of-way, 302 miles. The land owned for transmission right-of-way approximates 4900 acres.

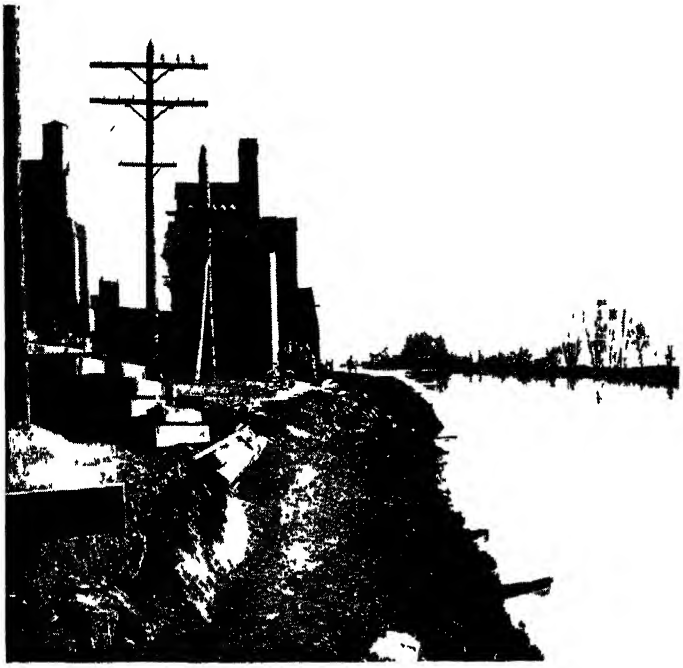
In addition to the transmission system above described, The Niagara Falls Power Company owns various high-tension circuits between Niagara Falls and Buffalo, and others connecting with the Niagara, Lockport and Ontario Power Company's lines, all on steel towers.

Distributing Systems: The output of the generating plants of The Niagara Falls Power Company is divided about equally between the electro-chemical industries on the Niagara frontier and direct service as light, heat and power.

INTERIOR OF THE CHARLES R. HUNTLEY STATION (LOOKING SOUTH)
Showing panels for location of Memorial Tablet

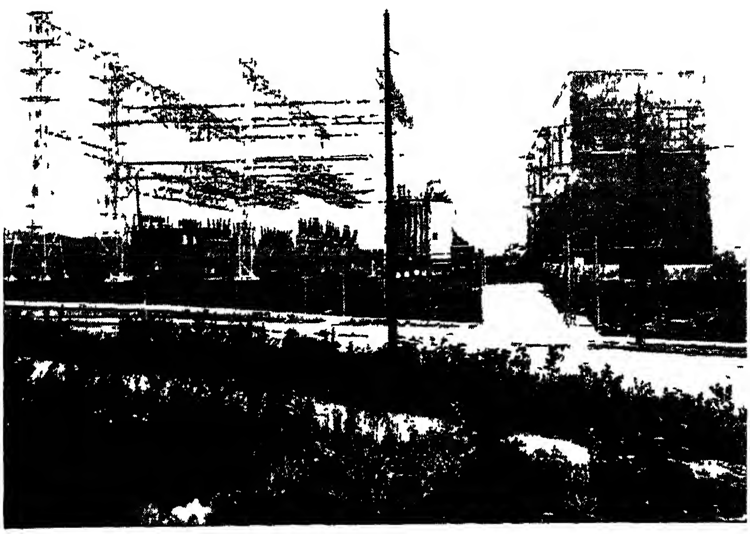
The Buffalo General Electric Company is the largest retail distributing unit in the Buffalo, Niagara and Eastern group. It serves a population of about 600,000, with domestic and commercial users numbering 148,891 and has a connected load of 495,800 kilowatts.

Summarizing: The power distributing agencies of the operating companies controlled by Buffalo, Niagara and Eastern Power Corporation make power available to about 450 cities, villages, towns, and lighting districts, located in a zone some 300 miles from east to west and 100 miles from north to south, having approximately 500,000 homes of which 80 per cent are either direct or indirect customers of the system.



TERMINAL HOUSE NUMBER ONE, BUFFALO, NIAGARA AND EASTERN POWER CORPORATION

The station that first received Niagara power in Buffalo, 1896



TERMINAL STATION "D", BUFFALO, NIAGARA AND EASTERN POWER CORPORATION

The station through which passes the larger portion of the electric energy that is delivered from the generators at Niagara Falls over the transmission lines to Buffalo, from whence it is distributed over the associated companies' lines of high tension transmission south and east, beyond the state lines

Volume One

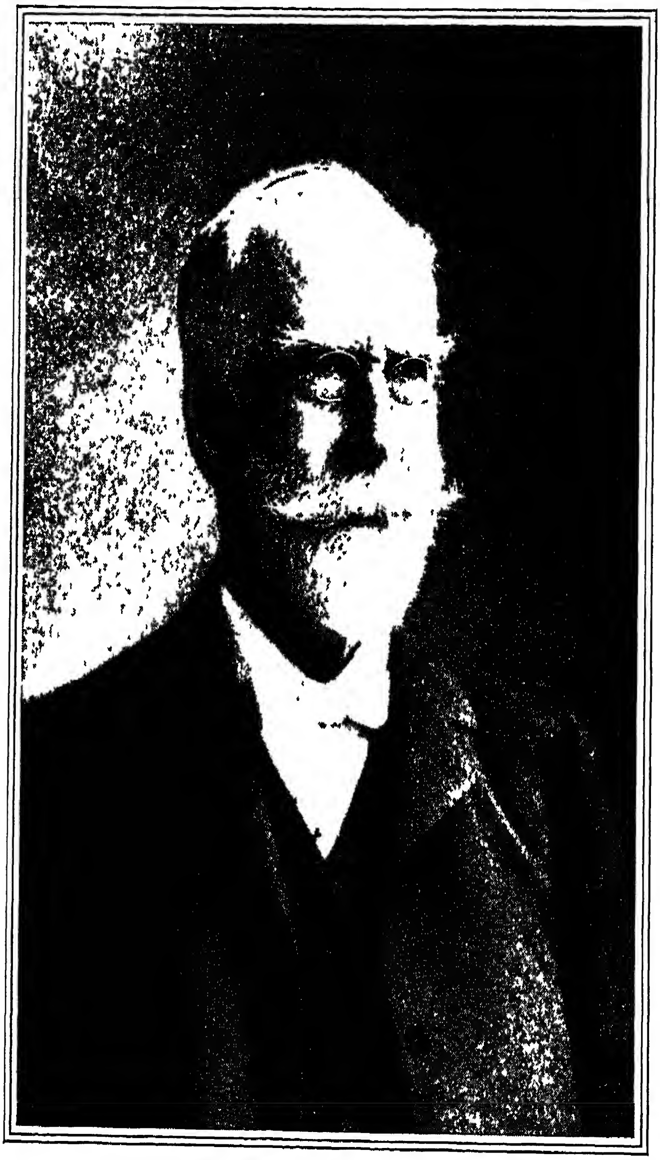
APPENDICES A–G

APPENDIX A

A TRIBUTE

DR. COLEMAN SELLERS

BY LEWIS B. STILLWELL



COLEMAN SELLERS, D SC., E.D.
1827–1907

Chief Engineer
THE CATARACT CONSTRUCTION COMPANY

President
THE NIAGARA FALLS POWER COMPANY

Coleman Sellers

A TRIBUTE TO DR. COLEMAN SELLERS

I first met Dr. Coleman Sellers in the summer of 1890 in London. As engineering adviser to the recently formed Cataract Construction Company, he and Mr. Edward D. Adams, the president of that company, were seeking ideas and suggestions which might be useful in solving the great problem of utilizing the power of Niagara Falls. With this object in view, Mr. Adams had invited a number of engineers from time to time to meet the Doctor and himself to discuss the subject. I happened to be in London at the time on special detail from the staff of the American Westinghouse Electric Company and, with Mr. Reginald Belfield, electrician of the British Westinghouse Electric Company, Ltd., was invited by Mr. Adams to meet Dr. Sellers and himself at Brown's Hotel in Dover Street.

At the outstart, I was greatly impressed by Dr. Sellers' personality and keenness of mind. At that time, he was sixty-three years of age and he brought to the consideration of the problem a judgment trained by many years of active and varied engineering experience. He brought also an enthusiastic interest rarely found in one no longer young As I realized increasingly in later years, enthusiasm, earnestness and a keen interest in the matter in hand at all times characterized both the Doctor's work and his play.

At our first interview, I was impressed particularly by the nervous energy with which he set forth various tentative plans which he had suggested. Later, when the Niagara Power Commission was organized and prizes and bonuses were offered for the best plan for utilizing power at the falls, Mr. Belfield and I were very keen to have the American Westinghouse Company submit plans for the development and distribution of power from a central plant by polyphase alternating current, but Mr Westinghouse would not consent. As he put it bluntly when I saw him a few months later in America "These people are trying to secure $100,000 worth of information by offering prizes, the largest of which is $3000. When they are ready to do business, we will show them how to do it."

Early in 1893, I again came in contact with Dr Sellers, when, in response to an invitation from Mr. Westinghouse, he and Professor Rowland visited Pittsburgh to test the newly developed rotary converter and to determine the effect of comparatively low frequencies upon incandescent lamps. From that time until 1897, as engineer of the manufacturing company which constructed and installed the first generators and their electrical equipment for the Niagara plant, and subsequently for three years as electrical director of The Niagara Falls Power Company, it was my great, good fortune to see much of the Doctor and of his work. No experience perhaps could give one a more comprehensive or accurate knowledge of his character and ability than could be acquired during such a period of close professional relationship, first, from the standpoint of a representative of the contracting company, and, later, from the standpoint of mutual interest and co-operation in the work of the Power Company. During all those years and in all relations, Dr. Sellers' attitude was invariably that of the ideal engineer—patient, always co-operative, zealous and tireless in protecting the interests of his client but never unjust to others. Seeking to construct no monument to himself, his sole object was to assist in the creation of a successful enterprise and the solution of a fundamental engineering problem.

To understand and appreciate the importance of Dr. Sellers' work at Niagara, it is necessary to realize the state of the art of power transmission at the dates when the

decisions of The Cataract Construction Company and of The Niagara Falls Power Company were made. The most definite plan which had been suggested before Mr. Adams and his associates acquired their charter contemplated an exclusively hydraulic development, a canal of considerable length being used to convey water to mills and factories located at various points convenient to the canal and a parallel outlet tunnel approximately 150 feet beneath the surface, discharging into the Niagara gorge below the falls. The power for each mill and factory, or closely adjacent group of mills and factories, was to be developed by its own hydraulic turbines, receiving water from the canal and discharging it into the outlet tunnel. As an alternative to this plan, which was in line with American practise at Holyoke, Manchester, and elsewhere, the possibility of one or more large centrally located plants, with some method of transmitting and distributing power, was considered. In presenting its problem, the Company indicated no prejudice or preference. The question asked was simply "How can the power at Niagara best be utilized?"

Under such conditions, the work of The Niagara Falls Power Company, demanded from its technical advisers skill, vision and judgment of a high order. Fortunately, the management of the Company was eminently wise and far-sighted and under its direction the minds of a selected group of the ablest scientists in America and Europe were brought to bear upon the problem of utilizing the power of the Great Falls From Europe, came Lord Kelvin, Mascart, Turrettini, Unwin and Forbes From America, came Sellers, Herschel and Rowland. Plans and suggestions were obtained also from many others at home and abroad.

Naturally, the plans suggested and, in many cases, strongly advocated, were various and often divergent. The problem of constructive development faced was complex and difficult. Its solution called not only for analytical and constructive ability of a high order, but for untiring patience, foresight, and, above all, for sound judgment.

From 1890 to 1893, the engineers selected by Mr. Adams and his associates were engaged in their far-reaching investigation. During this time, Dr Sellers, by his character, his zeal, and his sound judgment, established himself gradually in the confidence of the board until, by making him president and chief engineer of The Niagara Falls Power Company, and requiring his approval of all construction plans, they placed upon him full responsibility for deciding all engineering questions involved in their enterprise

Prior to 1890, the practicability of transmitting large amounts of power by electricity had not been demonstrated. In America, the determining steps in the development of the art of electric transmission were taken between 1885, when the idea of supplying incandescent lamps by alternating current through the intervention of transformers was brought to America, and 1895, when the first alternator was put into commercial service at Niagara. Since then, progress in this field has been measured by a gradual increase in size and efficiency of hydraulic and electric units, and, by step-by-step progress, in the development of high-tension insulators and the mechanical supports for transmission circuits. The first plant of The Niagara Falls Power Company involved steps relatively greater than any since taken. In those early days applicable theory was in its infancy, while practical precedent on a comparable scale did not exist.

The extent to which the judgment and painstaking investigation of Dr. Sellers influenced electrical development in America along lines now well established has not generally been recognized. As a member of the International Niagara Commission, he

opposed successfully a resolution moved by Lord Kelvin himself which aimed to exclude from further consideration all systems of electrical power transmission other than direct-current systems. Dr. Sellers wisely took the ground that the Commission's knowledge of the possibilities of the alternating current at that time was not sufficient to justify action which would close the doors to that system. Fortunately, his opinion prevailed. Few at this time would question the soundness of his judgment.

When the rapid development of alternating-current lighting and power systems led to general recognition of the transformer as the key to the problem of electrical transmission, advisers both within and without the organization presented for consideration the claim of various voltages and frequencies The two-phase and the three-phase systems had their respective advocates and strong supporters of various direct-current systems still were active. The electrical experts of The Cataract Construction Company failed to agree in regard to various essential features and in exercising his power of supervision and approval of all plans, Dr. Sellers accepted heavy responsibility not only in his own special field of mechanical engineering but in the hydraulic and electrical fields as well.

From 1889 to 1893, many important questions of engineering practise, in respect to which there is now practical unanimity of opinion, were earnestly debated In those years, the Doctor, sound in his judgment, conciliatory toward others, untiring in his effort to secure for his company what would stand the test of time, was the adviser whose counsel chiefly guided his company in regard to all technical questions. His broad knowledge of physical science and his long experience in dealing with mechanical problems qualified him pre-eminently in an enterprise involving large investment in a new field From personal knowledge, I can testify that his impersonality, his enthusiastic energy and his courage in assuming great responsibility were in every way admirable.

The far-reaching influence of the first plant of The Niagara Falls Power Company upon the development of the art of transmitting power by electricity has been widely recognized and instances might be multiplied in which his foresight avoided or skill surmounted difficulties which but for him would have handicapped seriously the remarkable engineering and industrial development to which that plant contributed so much of value

As an engineer, he earned the highest respect of his associates and of all with whom he had dealings. As a man, he won not only the respect but also the affection of all who were admitted within the circle of his friendship

Lewis B. Stillwell

December 31
1924

Under the above date Mr. Stillwell wrote Mr. Adams when sending him the above tribute to Dr. Sellers, stating,

"I appreciate highly the opportunity to incorporate my tribute to the Doctor in your forthcoming volumes.

"I knew the Doctor well enough to appreciate keenly the intense satisfaction it would have given him could he have foreseen that you would complete your great work in connection with the Niagara enterprise by becoming its historian."

APPENDIX B

EROSION AND RECESSION OF NIAGARA FALLS

NIAGARA FALLS

ITS PAST, PRESENT AND PROSPECTIVE CONDITION, EXPLAINED BY JAMES HALL, STATE GEOLOGIST, IN HIS FINAL REPORT OF THE FOURTH GEOLOGICAL DISTRICT OF THE STATE OF NEW YORK, 1843, FROM WHICH HAVE BEEN TAKEN THE FOLLOWING EXCERPTS

The conclusion then, seems inevitable, that the river has been the great agent in excavating its own channel, from near the escarpment between Lewiston and Queenstown, to the present position of the cataract; that the recession has been aided by the character of the rocks, presenting alternate hard and soft strata; and that the descent was overcome, not by one perpendicular fall, but by several. In support of this latter assertion, a single analogous case will furnish stronger evidence than a long argument. The course of the Oak-orchard creek, in Orleans County, is over the same strata, and exhibits the succession of falls and rapids, precisely in the manner I have just enumerated. The quantity of water, however, in the stream, is too small to produce anything like a degree of recession to compare with the Niagara River. . . . . .

Whatever facts and arguments may be advanced to prove the existence of phenomena indicating the former action of the sea in excavating the Niagara channel, and whatever objections may be advanced for or against other theories, I am fully convinced, from the facts presented, that the existence of the falls and the Niagara River, in their present position, is of very recent date geologically.

We come now to consider the future recession of the Niagara Falls, and its consequences. This is a subject on which many speculations have been hazarded, but no one appears to have undertaken the calculation with a full knowledge of the geology of the district, or to have taken into account the many disturbing influences. At the present time, the cliff over which the water is precipitated, is nearly equally divided between thick-bedded limestone and soft disintegrating shale. It is by the action of the spray from the falling water upon the shale undermining and leaving the limestone unsupported, which falls down by its own weight, that the falls recede from their present position. Now if we believe the statements of those who have resided at the falls, the recession has been about fifty yards within the last forty years, but from all the data I have been able to obtain, this appears to be much too great an estimate, indeed, it is extremely questionable if the fall has receded as many feet within that time. The central portion of the Horseshoe Fall recedes more rapidly than any other part, for here the greatest force of the river is exerted We know, likewise, from the testimony of all residents at this place, that the American Fall is becoming more curved in its outline, whereas, formerly it was nearly in a straight line. The successive descent of large masses of limestone, and the still continued overhanging of the table rock, prove very conclusively the unremitting action of water and air upon the shale below.

In the absence of established landmarks, we are compelled to leave the rate of recession unsettled for the present. The accompanying[1] trigonometrical map of the falls will furnish the means of doing this, by the monuments which have been established, and which may be considered as permanent points of reference for the future.

Leaving out of view the time or rate of recession, we have sufficient data to establish with certainty the future changes which will supervene, allowing the recession to go on as it is now doing. The lower half of the rock at the cascade, or about eighty feet, is of soft shale, the limestone above being of equal thickness; higher still is about sixty feet

[1] See Chapter XX, page 403, of Geological Report of James Hall, Geologist.

of thin-bedded limestone, forming the rapids. Now these beds dip to the south at the rate of about twenty-five feet in the mile, and the declivity of the bed of the river is about fifteen feet in the mile from the falls to Lewiston. It follows, therefore, that as the falls recede, there will be a less amount of shale above water, owing to the dip; and to this must be added the amount of declivity in the river bed, both together making forty feet. So that when the fall has receded one mile, the surface of the water will stand at a point in the shale half way between the present surface of the water and the bottom of the limestone. Going on at this rate for another mile would take away from the fall forty feet more of the shale, so that the surface of the river would then stand at the base of the limestone.

The cataract would then have a solid wall of limestone to wear down, the river beneath protecting, in a great measure, the undermining action upon the shale. During this time, and at the end of the first mile, the falls would have arrived at the present site of the commencement of the rapids, and thus about sixty feet more of limestone would be added to the height; unless from its thin-bedded character it continued to recede faster, and thus remain a rapid. In this case, there would be a fall of 140 feet at the end of the first mile, and one of 100 feet at the end of the second mile.

At this period, then, we are to contemplate the cataract of Niagara as having receded two miles, the shale having disappeared beneath the river, and the cascade presenting a solid wall of limestone 100 feet high, and a rapid of forty or fifty feet (o, m) beyond. The recession will then go on very gradually; and so soon as masses from this cliff have fallen down to fill up the river bed, as they inevitably will in a great measure, then the base will be protected so effectually that little influence will be exerted by the force of the water. Eventually, however, the cliff will be broken down, and huge fragments piled up below, until the cataract will be nearly lost amid them This state of things will continue for a long time, the height gradually diminishing, till the river has cut its way back for two miles further, when there will be no thick-bedded limestone above water, and the higher beds will form a rapid as before.

This point of meeting between the surface of the river below the fall and the top of the thick-bedded limestone, will be about one hundred feet lower than the top of the present cascade; and as there will be forty feet of rapids in the thin-bedded limestone within a short space, as there now is, it follows that there will be added to the descent of the river beyond the rapids, one hundred feet more than at present, as the surface of the limestone has dipped to that amount. The whole fall in the river at that time, from Lake Erie to the point of junction between the limestone and water below the rapids, will be about one hundred and sixty feet. The distance between this point and the outlet of Lake Erie is occupied by nearly uniform soft layers; and after a partial wearing down of the limestone forming the rapids, the descent will be equally distributed over the whole extent of sixteen miles, giving a uniform declivity of about ten feet in the mile, or one-third less than the present declivity in the bed of the river from the falls to Lewiston. From the nature of the bed of the river for sixteen miles below Lake Erie, it may be doubted whether this rapid descent along the whole distance would be continued; for the stream, having no heavy blocks of rock to remove, would keep its channel clear with a far less declivity; and should this prove the case here, we might still have a fall of a few feet, at the outlet of Lake Erie, over the limestone succeeding the salt group.

Whether such a fall would occur depends upon the solution of the problem regarding the required declivity in the bed of the river below Lake Erie. Whichever way it may occur, it will make no material difference in the great result, which will be either a continuous rapid stream from Lake Erie to Lewiston, or a rapid stream with a low fall at the outlet of Erie. If present causes continue to operate as now, such will be the consummation of the grand cataract of Niagara.

APPENDIX C

June 25, 1825

Invitation to Eastern Capitalists and Manufacturers, signed by Augustus Porter and P B. Porter

January, 1847

To Capitalists and Manufacturers, signed by Augustus Porter

Undated, probably about 1877

Niagara Falls Canal Company, unsigned

APPENDIX C

June 25, 1825

Invitation to Eastern Capitalists and Manufacturers, signed by Augustus Porter and P. B. Porter.

January, 1847

To Capitalists and Manufacturers, signed by Augustus Porter.

Undated, probably about 1877

Niagara Falls Canal Company, unsigned.

NIAGARA FALLS

1825

INVITATION TO EASTERN CAPITALISTS AND MANUFACTURERS

The subscribers are proprietors of the lands which embrace the rapids and falls, on the American side of the Niagara; and also of Iris, Bath, and the other small islands lying in the rapids, and connected, by bridges, with the main shore. The situation is not surpassed, and probably not equalled, in the United States, as a site for the establishment of manufactures, whether viewed in reference to its intrinsic advantages, or to its exterior facilities for the collection of manufacturing materials, and the distribution of fabrics. The country in the vicinity of the falls is rich in soil, romantically beautiful in formation, and proverbial for salubrity. The pure and limpid waters of the Niagara—always flowing with an uniform current, and full banks—are as propitious to the health, as they are conducive to the comfort and luxury of its inhabitants. From the head of the rapids to the Great Falls, a distance of three-fourths of a mile, there is a regular succession of chutes, which give, in the aggregate, sixty feet of perpendicular descent, and the adjoining banks appear to have been expressly designed for the convenience of leading water from the river for hydraulic operations. Practically speaking, the extent to which water-power may be here applied is without limit. A thousand mills might be erected with the same ease, and equally accessible, as if on a plain, and each supplied with a never-failing water-power, at an expense not exceeding fifty dollars, and be at the same time, perfectly secure against the dangers of inundation. This position is connected with the grand canal by an excellent boat navigation of ten miles in length, terminating in the canal at the mouth of Tonnewanta creek, through a lock of five feet lift—and with Erie and the other western lakes, by a safe and uninterrupted sloop navigation. In the opposite direction, it is only seven miles distant from Lewiston, the head of the sloop navigation of Lake Ontario and the St Lawrence. The communication with Lewiston is, at present, by a good road, but will probably soon be improved by the substitution of a canal or railway. The extensive forests which border the Niagara, the lake and the canal, and cover the islands in the river, will furnish a cheap and abundant supply of fuel for manufacturing purposes, for many years to come, and until the canals, already commenced, between Lake Erie and the Ohio, shall open a ready and cheap access to the vast beds of stone coal with which the whole of that region abounds. Adjoining and attached to the mill seats, the subscribers own a tract of land on the main shore, amply sufficient for the site of a large town, which must soon grow up at this place; and for the accommodation of its inhabitants with out-lots. Iris Island contains about seventy acres of excellent land, the upper half of which might be covered with machinery, propelled by water-power; and the lower half, situated in the midst of the falls and rapids, where Nature courts the imagination in her most sublime, beautiful and fascinating forms, might be converted into delightful seats for the residence of private gentlemen, or appropriated to hotels and pleasure grounds for the accommodation of the numerous strangers who annually visit this spot. A number of manufactories, on a scale adapted to the wants of the immediate vicinity, have already been erected, and are now in successful operation at this place; among which are, a large and valuable grist-mill, saw-mill, two woollen cloth factories, two clothier's shops, several carding and spinning machines, a forge, paper-mill, etc.

NIAGARA POWER

The subscribers would sell the whole of their property at this place (with the exception of the farm and private buildings of one of the proprietors) together; or they would divide it into several parts, and appropriate to each any desired number of water privileges. They would, however, be most gratified by seeing it in the hands of a single company, in which they would be glad to be interested themselves to the extent of their means. Such a company, with a commanding capital, and under a well-organized and efficient administration of its concerns, might build up an establishment which would successfully compete with any thing of the kind in the United States; and would be, at once, highly useful and creditable to the country, and lucrative to themselves. The manufacture of woollen, cotton and linen goods, on an extensive scale—of iron, in all its numerous and extended ramifications, and of bread stuffs, might be undertaken to great advantage. The lake country is celebrated for the best and most abundant crops of wheat. An inexhaustible mine of iron ore, of the best quality, has lately been discovered on the margin of Lake Erie. The whole country abounds in wool, hemp and flax grow in great luxuriance, and cotton might, at present, be introduced at a moderate expense of transportation, through the Atlantic and the Erie Canal; and, at no distant day, still cheaper, through the Mississippi and the Ohio canals. The general deficiency of water-power that exists along the country of the lakes—the increasing, and, already immense, population which surrounds them—their remoteness from the Atlantic ports, and the profusion and cheapness of stock and provisions, are circumstances calculated to give this place a decided advantage over similar establishments in the eastern states, in a competition with European manufacturers. The inadequacy of capital in this part of the country to undertakings of this kind, added to the doubts which have, until very recently, existed in regard to the success of American manufactures generally, have hitherto prevented the improvements which this situation so powerfully invites. The title to the property is unquestionable, having been derived immediately from the state of New York.

Any information, connected with the subjects of this advertisement, will be cheerfully given by Augustus Porter, who resides at the falls, or by Peter B. Porter, at Black Rock.

Aug's Porter,
P. B. Porter.

June 24th, 1825.

TO CAPITALISTS AND MANUFACTURERS

With a view to the more convenient and extensive use of the unlimited water power at the Falls of Niagara, the subscriber has located a large raceway, to serve also as a navigable canal, commencing at a point on the shore of the river where the water is deep and navigable, above the great Falls, and terminating on the high bank about half a mile below. This canal, about three-fourths of a mile in length, has been surveyed, and levels taken by an experienced Engineer, who estimates the whole cost of the canal, with its appurtenances, of sufficient capacity to afford water power for at least sixty run of mill stone, within the sum of Thirty thousand dollars.

The front along the bank of the river near the lower termination of the canal, extending about three thousand feet (now unoccupied) can be most conveniently supplied with water from the canal, and is adapted to the building of large establishments, on a foundation of solid rock, and with any required head and fall.

The quantity of water that may be used can only be limited by the size of the canal, which may be enlarged to any extent, at an expense somewhat less in proportion than the cost of the one now proposed.

The Niagara River, the inexhaustible source, is unaffected by floods or droughts, and at the point where the canal is supplied, will be entirely free from obstruction by ice.

The subscriber now offers to sell the right of constructing and using such a canal, and so much land as may be desired, from twenty to one hundred acres at the lower termination thereof, to any person or persons who will undertake its immediate construction Or he will sell a less interest, retaining a part, and contributing to the improvement.

Further description of the property is not deemed necessary, but any desired information will be promptly communicated; and reference is made to WILLIAM A BIRD, ESQ., of Black Rock, and PETER EMSLIE, ESQ., Civil Engineer, Buffalo

AUGUSTUS PORTER

Niagara Falls, January, 1847.

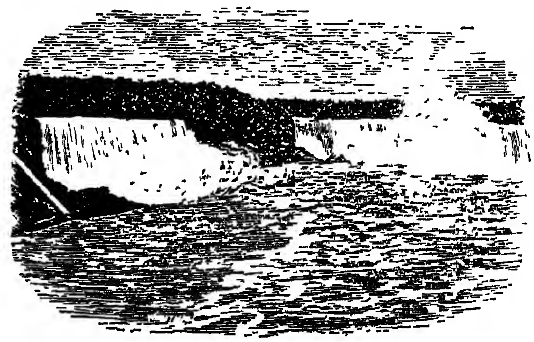
An outline map of Niagara Falls and Village was attached to this circular showing the location of the proposed Hydraulic Canal and Reservoir, by P Emslie, December, 1846. See page 232

Niagara Falls Canal Company,

Niagara Falls, Niagara County, New York.

J. F. Schoellkopf,
BUFFALO, N Y

A. M. Chesbrough,
NIAGARA FALLS N Y



Stephen M. Allen,
BOSTON, MASS

Miles Standish,
187, BROADWAY, N Y

The proprietors of the Niagara Falls Canal and property, including the greatest water power in the world and one hundred Mill and Factory sites with three hundred cottage lots, now offer the same for sale on reasonable and accommodating terms to all such as desire to establish and carry on manufacturing in Western New York. This property is so situated that the same can be used by the most humble manufacturer who may wish to run his own mill, or will meet the wants of Companies who desire to compete with the largest monopolies of the country in the production of any kind of manufactured goods. The Niagara River at this point turns at nearly a right angle, the great falls running across from the right angle almost in a continuation with one of the shores, the village lying within the angle

The Hydraulic Canal opens from the river about one mile above the Falls, and at the end of steamboat and other navigation, and runs directly across the town to the River bank about a quarter of a mile below the American Fall. A basin, to be continued about one mile in length along the river bank on the Company's lands, receives and discharges the water from the Canal through raceways or flumes to each factory site in quantities to suit, and with a perpendicular fall of any desired height not exceeding one hundred and ninety feet. The present size and capacity of the Canal at its mouth is sixty-six feet in width, with ten feet depth of water which is maintained with slight variation throughout the whole year The depth of water in the basin below is eleven feet, and canal boats pass without difficulty. Neither in winter nor at any other time during the year is there trouble from anchor or floating ice, and the whole water power is a perfectly uniform one. The canal is cut through solid limestone rock, and is about one mile in length, the average cut being twenty-two feet, with perpendicular walls and no wash of banks to make the water impure. The Canal can be enlarged to the width of one hundred feet, and building stone for factories can be quarried from its banks and floated down in boats to any point desired.

The facilities for the transportation of freight both by land and water are unsurpassed in the United States. The New York Central and Erie Rail Roads cross the lands of the Company and can be connected by side tracks of a few rods in length with the banks of the Canal or factories on the same, thus connecting with all the Rail Roads in the United States and the Canadas. Canal Boats loaded in New York City or the Western States, can unload and load again in the canal basin within a

quarter of a mile of the American Fall. Vessels loaded on Lake Superior, Michigan, or at any of the lake ports of the West can discharge and reload at Niagara Falls for any American or European port. This central point for the manufacturing business of the States, Canada, or for the exportation of manufactured goods to any part of the world, has many superior advantages of location as well as of water power.

The costs of living are less than in most manufacturing districts, and taxation remarkably low. The great West is open for every supply from that region while it is a notorious fact that many other of the necessaries of life can be sold cheaper than in New York City. Coal and iron can be delivered on the line of the Canal, as can almost every other commodity needed in manufacturing, from the cars or vessels in which they are first placed for transportation.

The sites for factories and other mills for every variety of manufacture will be sold low according to location and size, and the water at one thousand dollars per square foot of open weir surface at the head of the Canal, and the opening in the gates below to correspond in size to the square of water purchased, whatever that may be. Therefore persons can purchase one foot or more upward to ten square feet as they may wish at the same rate, and may use as much of the fall as they please.

J. P. Frizzell, Esq., an experienced engineer of Boston, estimates that a square foot of water at the entrance of the Canal which would be one six hundred and sixtieth part of the whole in-flow of water, with a velocity of two and a half cubic feet per second

On a fall of twenty feet (20 ft) will give 4 16 horse power
On a fall of thirty feet (30 ft) will give 6 25 horse power
On a fall of forty feet (40 ft) will give 8 33 horse power.
On a fall of fifty feet (50 ft) will give 10 41 horse power
On a fall of sixty feet (60 ft) will give 12 50 horse power
On a fall of one hundred feet (100 ft) will give 20 83 horse power
On a fall of two hundred feet (200 ft) will give 41 67 horse power

This is a much more liberal estimate for loss of power upon water-wheels than is generally allowed. By multiplying, any additional power will be given by adding any number of square feet of water desired in the purchase

APPENDIX D

CIRCULARS TO STOCKHOLDERS

Number 16, 1892

Number 65, 1903

Number 84, 1918

CIRCULAR No. 16

OFFICE OF

THE CATARACT CONSTRUCTION COMPANY,

MILLS BUILDING, NEW YORK, June 10, 1892.

To the Subscribers under the Agreement of January 17, 1890·

In the Annual Report to the Stockholders of the Cataract Construction Company, dated July 31, 1891, reference was made to the proposed formation of a

LAND COMPANY

for the development of the residential tract of about 400 acres reserved for this purpose by the Niagara Power Company from the lien of its mortgage.

The scarcity of available houses and the necessity of providing proper homes for the families of the better class of operatives already seeking accommodations at Niagara Falls have induced the Directors of this Company to proceed immediately with their plans for the construction of suitable dwellings and the preparation of the lands appropriated for such improvements.

THE NIAGARA DEVELOPMENT COMPANY has been organized under the Laws of the State of New York, with the following officers and directors (it being now intended that the officers and directors of the Construction Company, the Land Company and the Terminal Railway Company shall be identical)

EDWARD D ADAMS, *President*

FRANCIS LYNDE STETSON, *First Vice-President.*

EDWARD A. WICKES, *Second Vice-President*

WILLIAM B. RANKINE, *Secretary and Treasurer.*

GEORGE S. BOWDOIN, *Director.*

CHARLES F. CLARK, *Director.*

CHARLES LANIER, *Director.*

JOSEPH LAROCQUE, *Director.*

DARIUS OGDEN MILLS, *Director.*

FREDERICK W. WHITRIDGE, *Director.*

CHARLES A. SWEET, *Director.*

GEORGE B. BURBANK, *Chief Engineer.*

The Development Company has an authorized capital of $1,250,000, to be issued as

Common Stock	$750,000
Preferred Stock	500,000
Total	$1,250,000

all divided into shares of $100 each, and with equal voting power.

The Preferred Stock is entitled (both as to principal and dividends) to a preference over the Common Stock in the distribution of assets and income, and to cumulative dividends at the rate of eight per cent. per annum, payable out of net profits July 1 and January 1 in each year; no payment to be made before July 1, 1893, nor for any period prior to January 1, 1893.

The Preferred Stock will be convertible into Common Stock, share for share, at the option of the holder at any semi-annual period.

It is provided that no mortgage lien can be created without the approval of two-thirds in amount of the Preferred Stock outstanding at the time of the execution of any such mortgage.

In view of the benefits to accrue to the Niagara Power Company, from this necessary development of a residential tract, and also in view of recent sales of neighboring property of similar character at prices exceeding $2,500 per acre, the Power Company has agreed to sell its above-mentioned residential tract, comprising 368 acres, at the price of $2,038 per acre, amounting to $750,000, accepting in payment therefor at par all the Common Stock of the Land Company. This land was appraised, in writing, June 1, 1892, by disinterested experts of large experience, at $3,000 per acre, or more than $1,100,000 in all.

To provide funds for the maintenance and improvement of this property and the construction of dwellings, 4,800 shares of the Preferred Stock of the par value of $480,000 are offered for sale at $100 per share, subscriptions to be payable in installments of not more than 10 per cent. each, not less than one month apart Certificates of full-paid Preferred Stock will be delivered on or about January 1, 1893, for all installments then paid and for interest thereon at eight per cent. from date of payment. Scrip redeemable in Preferred Stock will be issued for fractional amounts.

It is believed that this stock, having a first claim upon 368 acres of valuable land within the limits of the City of Niagara Falls, *which cannot be mortgaged except with the consent of holders of two-thirds of this Preferred Stock*, and which is to be used not for the purchase, but only for the improvement and maintenance of the property, is specially valuable as an investment

In the same Annual Report the project for a

TERMINAL RAILWAY

was set forth. It has become necessary, in the opinion of the Directors of this Company and the Power Company, that this Railway should now be built for the delivery of materials for construction and other materials to the lessees of the Power Company.

The line as located is about six miles in length, and, excepting less than one-fifth of a mile, is entirely within the estate owned by the Power Company. By its connection with the New York Central & Hudson River Railroad, the Erie Railway, and docks on the Niagara River, the tenants of the Power Company and all rail and water lines of transportation are to be placed in direct business relations. A considerable amount of business is already awaiting this railroad, and much more is proposed to it, so that an immediate earning capacity seems assured.

The Niagara Junction Railway Company has been organized under the Laws of the State of New York, with the same Directors and Officers as the Land Company, and with an authorized capital to be issued as

Common Stock	$160,000
Preferred Stock	140,000
Total	$300,000

all divided into shares of $100 each, and with like voting power

The Preferred Stock will have a preference over the Common Stock only as to income, limited to cumulative dividends at the rate of eight per cent. per annum, payable out of net profits July 1 and January 1 in each year, no payment to be made before July 1, 1893, nor for any period prior to January 1, 1893.

The Preferred Stock will be convertible into Common Stock, share for share, at the option of the holder at any semi-annual period

By the provisions of the Trust Deed, securing the first mortgage bonds of the Power Company, the right of way for a railway through the property of that Company, as determined by the Power Company prior to July 1, 1892, was expressly exempted from the lien of that mortgage.

The land necessary for a double-track railway, with connections, sidings and yard facilities, being in all 166 acres (of which about 70 acres of yard is subject to the general mortgage), is to be conveyed to the Junction Railway Company for the sum of $160,000, payable in its entire Common Stock at par This land was appraised June 1, 1892, at $2,500 per acre, or more than $400,000 in all.

For acquisition of right of way for a limited part of the line not derived from the Power Company, for construction, for purchase of equipment now necessary, and for operation as a single-track line, 1,200 *shares* ($120,000 *par value) of the Preferred Stock are offered for sale at* $100 *per share, subscriptions to be payable as and when called at option of Company on or before January* 1, 1893, *when certificates of fully-paid Preferred Stock will be issued for all payments and for interest at eight per cent from the date thereof. Scrip redeemable in Preferred Stock will be issued for fractional amounts.*

Should the business of the Company so develop as to require provision for extensive improvement, equipment and operation, as is now expected, a mortgage not exceeding $500,000, to be devoted to those purposes, may, when authorized by stockholders, be provided.

It will be observed that the Niagara Power Company retains the control of both the Land Company and the Junction Railway Company, through the ownership of a majority of their respective capital stocks, as specially authorized by its charter, and that, in the case of each corporation, land is furnished by the Power Company for Common Stock, so that Preferred Stock, issued only for improvements and maintenance, gets the benefit of large landed interests without money payment therefor.

The above-mentioned Cumulative and Convertible eight per cent. Preferred Stocks are now, by arrangement with the Railway Company and Land Company, offered at par

to the present Subscribers, under the Agreement of January 17, 1890, to the aggregate amount of

$480,000, or 4,800 shares of the Niagara Development Company,
$120,000, or 1,200 shares of the Niagara Junction Railway Company, being at the rate of

$1,200, or 12 shares of the Land Company, and
$300, or 3 shares of the Junction Railway Company,

$1,500, or 15 shares in all, for each

share of Capital Stock of the Cataract Construction Company owned by the Subscribers to said agreement.

That is, each Subscriber is entitled for each share of Cataract Stock held by him to subscribe for $1,500 of the two Preferred Stocks.

Subscriptions for either or both of such stocks at par will be received at this office until 3 P. M., Friday, July 15, 1892, and will be payable in cash installments as above stated. A cheque for ten per cent. must accompany each subscription

All shares not subscribed for as above will be disposed of by the Board of Directors as they may deem for the best interests of the respective companies, preference being given to applications from stockholders for amounts in addition to their pro rata allotments.

With reference to this contingency Subscribers are invited to indicate how much stock of either Company they may desire in case more than their respective proportions shall remain open for allotment.

A copy of the certificate of each corporation is herewith inclosed, showing the exact status of each corporation and its Preferred Stock.

No commissions or allowances of any kind are made or paid to anyone on account of these subscriptions, the intervention of the Cataract Construction Company being solely on account of its great interest in the property and development of the Niagara Falls Power Company and its attendant enterprises.

By order of the Board of Directors,

THE CATARACT CONSTRUCTION COMPANY
by
EDWARD D. ADAMS, *President.*
WILLIAM B. RANKINE, *Secretary.*

Circular No. 65.

OFFICE OF

THE NIAGARA FALLS POWER COMPANY

BOARD OF DIRECTORS

EDWARD D ADAMS
JOHN JACOB ASTOR
GEORGE S BOWDOIN
CHARLES F CLARK
CHARLES LANIER
JOSEPH LAROCQUE
D O MILLS
VICTOR MORAWETZ
DANIEL O'DAY
WILLIAM B RANKINE
FRANCIS LYNDE STETSON
FREDERICK W WHITRIDGE
EDWARD A WICKES

ROOM 29, EIGHTH FLOOR, MILLS BUILDING,

NEW YORK, June 16, 1903

To the Holders of the Preferred Stock of
Niagara Junction Railway Company, and of
Niagara Development Company, and

To the Holders of Scrip of
Niagara Development Company.

The Stockholders of The Niagara Falls Power Company at their annual meeting on the 2nd inst. instructed the Board of Directors to offer in behalf of that Company to purchase from the holders thereof

(1) Any and all of the Preferred Stock of Niagara Junction Railway Company in the amount of $140,000 at par and accrued interest at six per cent per annum from the date of its issue, January 1, 1893

(2) Any and all of the outstanding Preferred Stock of Niagara Development Company in the amount of $421,200 at par and accrued interest at the rate of six per cent per annum from the date of its issue, January 1, 1899

(3) Any and all of the non-interest bearing scrip of Niagara Development Company outstanding in the amount of $113,498 24 at par, payments to be made for such stocks and scrip in stock of The Niagara Falls Power Company at par.

Pursuant to such authority, and by instructions of the Board of Directors, The Niagara Falls Power Company now offers on the terms stated above to purchase and to pay for any and all of the stock and scrip above described. You are invited to indicate upon the enclosed blank, to be returned to this office, your willingness or unwillingness to accept such offer which will be open until September 1, 1903, all purchases being made as of July 1, 1903, and interest being computed to that date. If you accept the offer please enclose with your acceptance your certificates duly endorsed for transfer to The Niagara Falls Power Company for which suitable receipts will be delivered exchangeable into the stock of The Niagara Falls Power Company when increased and issued by order of the Stockholders.

Adjustments will be made in respect of the fractions and sums under $100 in the total amount of stock of The Niagara Falls Power Company to which you may be entitled, the Company having made arrangement so that fractional amounts under $100 of that stock may be sold to you at par or purchased from you at 98.

In the event of the acceptance of this offer by the holders of more than two-thirds of such stocks and scrip, a special meeting of the stockholders of The Niagara Falls Power Company will be called to authorize an increase in the present issue of its stock in an amount sufficient to enable that Company to deliver stock in exchange for the temporary receipts above described.

By Order of the Board of Directors,

THE NIAGARA FALLS POWER COMPANY,

By

William B. Rankine,

Treasurer.

CIRCULAR No. 84.

THE NIAGARA FALLS POWER COMPANY

NIAGARA FALLS, N. Y.

15 BROAD STREET,
NEW YORK CITY, March 1, 1918.

To the Stockholders of
The Niagara Falls Power Company.

The following report and certified financial statements for the year 1917 are respectfully submitted by the Board of Directors

The Niagara Falls Power Company has been permitted since January 19, 1917, to divert water sufficient to operate its plant at full capacity, thus increasing its power output approximately 15,000 horse-power above the limits of restrictions imposed by the Federal Government ever since the enactment of the Burton Law in June, 1906, except for certain short periods of special relief.

Permits for the additional diversion were issued by the Secretary of War under authority of Joint Resolutions of Congress approved respectively January 19, and June 30, 1917. The resolution of January 19, limits the generation and use of Niagara power to the capacities of apparatus installed and in use at that date: Congress intending thereby to prevent additional uses of Niagara power during the life of the resolution and until further legislation by it

The permit, and the authority of the Secretary of War to grant like permits, will expire with June 30, next, unless meantime Congress shall take further action, it being expressly provided in the resolutions that a diversion of any water from the Niagara River after June 30, 1918, in excess of the limitations of the expired Burton Law shall be a misdemeanor punishable by heavy penalties.

The resolution of June 30, 1917, authorizes and directs the Secretary of War to make a "comprehensive and thorough investigation" of "the entire subject of water diversion from the Great Lakes and the Niagara River, including navigation, sanitary and power purposes and the preservation of the scenic beauty of Niagara Falls and the Rapids of the Niagara River, and to report to Congress thereon at the earliest practicable date," and appropriates $25,000 for that purpose.

The Cline bill mentioned in last year's annual report as then pending in Congress was agreed to by the House of Representatives February 8, 1917, but failed to be considered in the Senate.

By an order signed by the Secretary of War under date of December 28, 1917, the President of the United States requisitioned until further notice the total quantity and output of electrical power produced or capable of being produced by this Company as well as that delivered to it in the United States from Canada. The order provides that it must be given precedence over any and all orders theretofore placed with this Company. The order is depriving some of this Company's customers of power heretofore delivered them under contracts of long standing and for long terms, increasing the supply to others whose products the Federal administration considers more essential to the successful conduct of the war.

This Company is endeavoring in every way to co-operate with the United States War Department to make Niagara power of the greatest possible service toward winning the war.

That there is insufficient power at Niagara to supply present requirements is due largely, if not wholly, to the continued unwillingness of Congress since the question of Federal control of Niagara diversion was first raised in 1906 to enact permanent provision for the subject and to fix the status and the rights of the companies which had constructed expensive plants pursuant to authority of the State of New York and had been lawfully operating for many years before their rights were questioned.

During all that time this Company has stood ready upon any reasonable permanent settlement of its rights at least to complete its original undertaking This would have substantially doubled the present output of the American plant with little, if any, diversion of water above the amount now in use by it under the existing temporary permit.

In response to enquiries of the War Department made in 1913 this Company stated in a letter to the Chief of Engineers that

> "no one can be more desirous of meeting any increased demand for power than will be The Niagara Falls Power Company, the pioneer in the production of hydro-electric energy for industrial use . . . whose enterprise preceded any demand for electrical power and antedated any and all legal complications . . .
>
> "Preliminary estimates indicate the possibility of supplementing the present works of The Niagara Falls Power Company so as to utilize to the utmost practicable extent, between its intake and outlet, the potentiality of the waters by it diverted from the river. . . . To this end, however, an absolutely essential prerequisite would be the approval of the Federal Government of the right to use the water permanently, or for an adequate period, and under conditions promising a fair return."

Later in replying to further enquiries of the War Department, in 1916 when the prices of the required material and labor had advanced approximately 50 per cent., this Company further stated in a letter to Major H Burgess of the U. S Lake Survey, dated September 30, 1916,

> "Subject to confirmation by the Federal Government of our rights for the necessary water diversion for such a term and upon such conditions as will render it practicable to raise the required money, we shall be ready and would like to undertake the work as soon as the present abnormal conditions of the labor and material markets are adjusted to a basis that will permit the project to be carried out with due regard to economic considerations."

A statement in some detail was made in last year's annual report in respect of the indispensability of the products of Niagara power. Increases in the demand for those products have been brought about by the war in which this nation is engaged. The Federal authorities now have recognized the fact that the amount of Niagara power available is wholly inadequate for use in the production of sufficient quantities of the articles required to supply the nation's needs and at the same time to supply ordinary business requirements

Throughout the year the demands on both companies for power were far in excess of the capacity of the plants. Practically a power famine now exists at Niagara It is confidently believed that double the present output of all the existing plants would soon be absorbed for at least the duration of the war

The tenth unit in the plant of the Canadian Niagara Power Company was completed and placed in commercial service in January, 1917. The generating installation of that Company is now in excess of 100,000 horse-power. Its present head works, power house and tunnel are adequate for the installation of another large generating unit The Ontario Government, however, now claims that the present rights of the Canadian Company are limited to the production of 100,000 horse-power. In this view we are unable to concur.

Increases in production and sales by your Companies resulted in substantial increases in gross revenues. The increases were more than offset by greater operating costs and by large increases in taxes It also was considered proper to appropriate from surplus a substantial reserve against certain contingent liabilities, consisting in the main of possible further requirements under constructions which may be placed on recent War and Excess Profits Tax laws.

Among recent increases in operating costs is the expense of protecting both the American and Canadian plants against lawlessness. Military and also private guards are stationed at the Canadian plant and private armed guards at the American plant A protective enclosure has been built about the American plant

In the annual report for the year ended December 31, 1913, the opinion was expressed that this Company's "normal function generally should be the production of power for industrial uses and its transmission in large amounts for distribution by others" At that time the Board had negotiated, subject to consent of the stockholders of this Company, the sale of the majority shares of the Cataract Power and Conduit Company, which distributed in Buffalo Niagara power purchased of this Company The holders of more than 81 per cent of this Company's shares filed their written approvals of the sale. Following the policy then enunciated, the stock of the Tonawanda Power Company (2,500 shares of a par value of $100 each) was sold to a group in which were included Directors Rankine, DeGraff and Smith, who, however, took no part in the proceedings for the sale, in August last at $175 per share in cash, aggregating $437,500 The amount of $220,500 thereof, being the avails of 1,260 shares that had been pledged as collateral under the mortgages securing this Company's funded indebtedness, was deposited in trust with Central Trust Company of New York in substitution for the stock theretofore so pledged Subject to that lien a further pledge thereof was made to Bankers Trust Company as Trustee under the mortgage securing the Refunding and General Mortgage bonds of this Company, due January 1, 1932, in substitution for the like second lien to which that stock had been subjected under date of October 1, 1909. The balance of $217,000, being the proceeds of 1,240 shares, was paid into the treasury of the Company. As shown by the Treasurer's statement, the transaction resulted in a large profit to this Company.

The interest in the Tonawanda Company thus sold was subject to bonds to the amount of $150,000, secured by a mortgage on that Company's plant and properties. The sale was made subject also to an amended power contract pursuant to which the

Tonawanda Company will purchase power from this Company for and during the term of this Company's corporate life.

By resolutions of the Board of Directors, the Central Trust Company of New York was requested to subscribe for $1,500,000 of the United States First Liberty Loan 3½ per cent. bonds, and later for $500,000 of the Second Liberty Loan 4 per cent. bonds, to be held by it as Trustee as an investment of trust funds in its hands resulting from the sales of properties under the lien of the mortgage securing the 5 per cent. First Mortgage bonds of this Company due January 1, 1932. Allotments of $450,000 of the 3½ per cents. and $300,000 of the 4 per cents. were made and the $750,000 bonds are now held by Central Trust Company, as Trustee under said mortgage.

In addition to the subscriptions placed through the Central Trust Company of New York, this Company subscribed direct for $500,000 and was allotted $300,000 of the 10-25 year 4 per cent. convertible gold bonds (Second Liberty Loan of 1917). These are now held in the treasury of the Company.

The Canadian Niagara Power Company also subscribed for and was allotted $250,000 5½ per cent. bonds due December 1, 1922, of Canada's Victory Loan

Mr. Edward A. Wickes, who at the organization of The Cataract Construction Company in February, 1890, became its First Vice-President and a member of its Board and Executive Committee, and on June 6, 1899, was made First Vice-President and on February 1, 1910, President of this Company, resigned as President on July 10, 1917, urging that he had reached the age limit As a member of the Board of Directors, Mr Wickes continues his lively interest and active participation in the management of the affairs of the Company.

Mr. Stacy C Richmond, a member of the Board of Directors since December 9, 1914, was elected President to fill the unexpired term of Mr Wickes

The Board of Directors had hoped to incorporate in this report a short history of this Company's power development at Niagara to bring to your attention the state of the art of electric power production and use at the beginning of this enterprise and the part taken by your Company in its development. In collecting the necessary data it has been found that more time will be required than was at first anticipated, and accordingly, it has been determined to send the historical sketch to stockholders at a later date

By order of the Board of Directors.

STACY C RICHMOND
President

FREDERICK L. LOVELACE.
Secretary.

APPENDIX E

INTERNATIONAL NIAGARA COMMISSION

Invitation by The Cataract Construction Company, June 25, 1890, to Submit Engineering Projects for Consideration by the Commission

Report April 13, 1891, of Projects Submitted and Prizes and Premiums Awarded

LETTER OF INVITATION

June 25, 1890

See Chapter X, Page 183, for Introduction and Conclusion

The purpose of this Company, in organising this Commission, has been to ascertain the best system for this enterprise, and to have the questions involved considered by the highest available scientific authorities.

The following conditions of the proposed Competition have been settled with due regard to the customs prevailing in each country intended to be represented, so that no national prejudices need be raised.

In order to place all foreign competitors upon an equal basis with Americans, both for the Competition and the execution of the plans, it is proposed —

1. That £75 should be allowed for travelling expenses to such of the foreign competitors as may desire to make a personal examination at Niagara Falls, prior to Saturday, September 6th, 1890, the close of the Competition, due notice of such intention to make such examination to be given in advance of departure to the Secretary of the Commission.

2. (*a.*) That a commission of two and one-half per cent (2½%) on the cost of manufacturing machinery be paid to the author of projects adopted, in case no guarantee of performance be given, or superintendence of construction and installation required

   (*b*) This commission will be increased to five per cent (5%) in lieu of manufacturers' profits, in case the Company finds it advantageous to have machinery constructed in America, from working drawings purchased from the foreign authors, who offer to construct with proper guarantee of performance

The projects and the communications to the Commission, as well as its proceedings and reports, to be in the English language.

The dimensions of plans and all calculations to be expressed in English measures and the financial statements in dollars at the rate of five francs per one dollar and five dollars per pound sterling

The projects to be filed with the Secretary of the Commission in London on or before Saturday, September 6th, 1890, excepting those from America, which may be deposited on or before Friday, August 29th, 1890, with the Treasurer of the Company in New York, who will bring the same to London. No projects will be received after these dates to compete for the prizes offered.

The Commission is authorised to award the following prizes for the projects which it may consider the best adapted to the ends of this particular enterprise, taking into consideration economy of expenditure, convenience of arrangement for progressive enlargement, mechanical results from separate parts, final results per horse-power transmitted, and guarantees of performance.

(*a*) Hydraulic projects for the primary development of power by turbines or other water motors.
1st Prize £200. 2nd Prize £150.

(*b*) Projects for the transmission and distribution of power from the primary (*a*)*.
1st Prize £200. 2nd Prize £150.

(*c*) Projects combining both development and transmission (*a*) and (*b*) combined.
1st Prize £600. 2nd Prize £500.

The Commission is authorised to award two first prizes of £600 each in case two projects are found to be of equal merit.

There will be paid to each party submitting separate plans of sufficient importance and accepting and complying with all the conditions of the Competition:—

1. £100 to each party submitting one or more projects of (*a*) and (*b*)

2. £200 to each party or associated parties submitting projects (*c*).

The right is reserved to the Commission to withhold all prizes and compensation if in their judgment the projects are undeserving of the same

All projects are to become the property of the Company, but there shall be no obligation upon the Company to adopt any particular one, and it shall have the right to adopt a part of any or all projects. In case any project or part thereof shall be adopted, the Company shall give the author thereof due credit for the same and pay for the necessary working drawings, and shall pay in addition, pursuant to a contract to be arranged therefor, the commission aforesaid upon the net cost of all machinery constructed by others than the authors of the projects, or part thereof adopted

All questions that may arise under this Competition shall be subject to the absolute and final decision of the Commission, without recourse, but no claim will be considered after October 1st, 1890

The Competitors are required to submit in six copies:—**

1. Plans sufficiently detailed to permit an opinion to be formed by the Commission regarding the character of the construction proposed. All the special devices for security and regularity, electric, hydraulic, etc., must be shown by separate and descriptive drawings in detail.

2 Explanatory text, giving full information as to the methods proposed, time required for preparation of working drawings, and the manufacture of machinery, and installation of project, results expected, performance to be guaranteed, commercial values, and with references in detail to similar installations already constructed, if any, as evidence of practicability and economy.

3. Estimates of cost of furnishing working drawings prepared in feet and inches, for manufacture in America, of all machinery except pieces requiring special treatment by experienced hands. Such drawings, if demanded, to be made in

* Competitors who submit projects (*b*) for transmission and distribution only, should calculate upon a speed of 200 to 250 revolutions per minute on the shafts of the primary development (*a*)

** Five of these plans may be submitted in blue-print

accordance with American shop practice as to sizes, according to full information to be given by the Engineers of this Company.

4. Estimates of cost of machinery and all accessories with details thereof, delivered free on board at a port of regular and convenient shipment for New York or Niagara Falls.

The estimates of cost of rock and other excavation may be made at —

$0 25 (f 1.25) per c. yd. (0.7645 c. meter) for open earth cut.

$1 50 (f 7.50) per c. yd. (0.7645 c. meter) for open rock cut.

$4 00 (f 20 00) per c. yd. (0.7645 c. meter) for tunnels or other rock excavations in bulk, wholly underground, and at

$5 00 (f 25 00) per c. yd. (0.7645 c meter) for minor underground rock excavation by heading only.

The assumed cost of materials and labour for temporary and permanent construction of all kinds, not mentioned above, should be stated, in order that an equitable comparison may be made

The estimates of cost to the Company, per horse-power produced at the point of consumption by the methods proposed, may be made upon the assumption that the Company will have expended in the completion of its tunnel, 8,000 feet in length, etc., the sum of $4,000,000. Each Competitor should add to this sum whatever he may estimate to be the additional cost of his projects.

In calculating the commercial results per horse-power produced, transmitted, and distributed by the proposed project, allowance should be made for depreciation and for the service of installation, and in addition five per cent interest upon the total cost, including the aforesaid sum of $4,000,000

In considering these questions it may be assumed that there is —

1 Unlimited and never-failing water, with a comparatively small amount of sediment

2 Constant net fall or head of 140 feet (42 67 meters)

3 A tail race or tunnel, 8,000 feet (2,438 32 meters) long with a section of 490 square feet (45 54 square meters) and 18,148 cubic yards (13 874 cubic meters) per linear foot (.3048 meter) without lining, with a grade not exceeding 7 per 1,000 and exclusive of any excavations for wheels or water inlets.

4. Level and vacant land and low river banks readily available for the erection of manufactories, with access thereto by water and rail

5. About 10 feet (3.047 meters) of soil overlaying horizontal strata of rocks, all sufficiently hard to permit the excavation of chambers and shafts, wheel pits, tunnels, etc

Projects are invited for one Central Station, located at the head of the tunnel, for —

1. The economical development of as much power as the section of the tunnel, the head of water, and the hydraulic slope will permit, and—

2. Transmission and distribution of this power overhead or underground by electricity, compressed air, water, cable or other means to:—
   (*a*) A manufacturing district to be built up within a radius of four miles (6.44 kilometers), and
   (*b*) To the city of Buffalo, distant about twenty miles (32 18 kilometers).

The Central Station should be so designed.—

1. That a combination of methods of transmission and distribution may be employed according to the probable demand therefore by various classes of industries.
2. That a block of 50,000 horse-power may be specially designed for the Buffalo transmission, and
3. That the entire capacity of the tunnel may be developed gradually in blocks of from 10,000 to 20,000 horse-power each.

The methods of transmission and distribution should be those best suited to large manufacturing cities requiring—

1. Electricity for domestic, street and manufacturing purposes.
2. Water for power, domestic, fire and manufacturing uses, and
3. Air for power, ventilating and refrigerating

Opportunity will be given to all Competitors to appear before the Commission to give personal explanation of their projects.

It is believed that all necessary details for a correct understanding of this matter will be found in the photographs, maps and plans transmitted you herewith.

* * * * * * * * * * * *

LIST OF DOCUMENTS

ACCOMPANYING INVITATION TO INTERNATIONAL NIAGARA COMPETITION

JUNE 25, 1890

1. Map of Great Lakes with text explanatory of drainage area and volume of water
2. Map of country within a 20-mile radius of Niagara Falls, showing towns, population, etc.
3. Lake Erie Coast Chart, showing depth and routes of water from Buffalo to Niagara Falls.
4. War Department Survey, showing topography around Niagara Falls.
5. Colored Map of Niagara Falls showing State Reservation, lines of railway and shore line filling permitted on river edge of the company's property.
6. Photograph of perspective view of the falls and town of Niagara.

LIST OF DOCUMENTS—*Continued*

7. Photograph of cliff with location of tunnel mouth.
8. Photograph of company's property viewed from Canadian side.
9. Blue-print, showing location of tunnel and property owned by the company.
10. Blue-print, profile, showing location of tunnel
11. Sketch, showing Niagara group of rocks, section of tunnel and details of fall
12. Map of Buffalo and head of Niagara River.
13. Memorandum regarding city of Buffalo.

REPORT

ON THE

PROJECTS

SUBMITTED TO

THE INTERNATIONAL NIAGARA COMMISSION

PROF. W C UNWIN, F.R S.

1891

THE CATARACT CONSTRUCTION COMPANY having asked for a report on the plans submitted to the Commission, the Secretary has prepared the following statement. The Commission having separated, it is not possible to have an official report carrying the authority of the Commission. The general conclusions of the Commission have been communicated to the Cataract Company in the Report of Proceedings, and that report is confidential between the Commission and the Company.

W. CAWTHORNE UNWIN.

PROF. E. MASCART, the Commissioner from France, wrote from Paris to the Secretary, June 29, 1891.

I have just received and have read with great interest the remarkable Report prepared by Professor Unwin on the competition in regard to Niagara. This Report reproduces a very faithful image of the discussions which took place in the Commission.

E MASCART
Directeur
Bureau Central Météorologique

A group portrait of the International Niagara Commission will be found in Chapter X, page 180, and separate portraits of each commissioner are introduced in appropriate places in this volume. Prof. W. Cawthorne Unwin is the only survivor of this group at the date of publication and his reflections upon his connection with this enterprise will be found in Chapter XXVIII, Volume Two, "Reviews."

REPORT ON THE PROJECTS

SUBMITTED TO

THE INTERNATIONAL NIAGARA COMMISSION.

PROF. W. C. UNWIN, F.R.S.

PART I.

The Niagara River at Niagara Falls has long been recognized as capable of furnishing an enormous amount of mechanical energy and as having peculiar advantages for the development of water-power. Flowing from a great chain of lakes, which form reservoirs to a water-shed covering an area of more than 240,000 square miles, the Niagara River has an almost unvarying discharge, estimated at 265,000 cubic feet per second. The drop at the Falls, which creates the means of applying hydraulic machinery, is 150 feet, and this with the fall in the rapids above and immediately below the Falls gives a total head of 214 feet for driving hydraulic motors within a distance not greater than a mile and a quarter The variation during the year of surface level of the river is very small either above or below the Falls, and is chiefly due to the action of wind The ordinary changes of level do not exceed 1 foot in the river above the Falls or 5 feet below the Falls The greatest authenticated changes of level below the Falls, due to iceblocks in the river and other causes, amount to only $13\frac{1}{2}$ feet rise above mean level and 9 feet fall below it. The land on the United States side is almost a level plain, suitable for mill sites and for the construction of head-race channels. The river, turning at right angles immediately below the Falls, facilitates the construction of a tail-race tunnel. The rock strata of shale and limestone are strong and trustworthy for tunneling

The Cataract Construction Company has been organized to carry out a scheme for utilizing and distributing a part of the mechanical power available at the Falls They have purchased a tract of about 1,400 acres, which at its nearest point is about $1\frac{1}{4}$ miles above the Falls. A vertical shaft is being driven at this point nearly to the level of the lower river. Starting from the bottom of this shaft and debouching into the lower river a tunnel about 18 feet wide, 30 feet high, and of 490 square feet sectional area, with a slope of 4 per 1,000, is already in progress beneath the present town of Niagara. This tunnel is to serve as a tail-race to the hydraulic machinery for utilizing the water-power It is estimated to be capable of discharging with a velocity of perhaps 28 feet per second as much water as would be used by hydraulic machines developing 125,000 effective horse-power Large and commercially valuable as this enormous power would be, it is probably little more than 3 per cent of the power running to waste over the Falls, and its abstraction will probably not visibly affect their appearance.

At a distance of 18 miles from the tract purchased by the Cataract Company is the important city of Buffalo, and at a less distance the active manufacturing town of Tonawanda. It is contemplated in the project of the Cataract Company to transmit part of the power utilized to Buffalo and Tonawanda, where, provided it can be rented at a suitable price, it would replace the steam-power at present employed.

Given the conditions thus briefly indicated, two classes of problems press for solution: (1) As to the best method or methods of developing the power in a form available for application; (2) As to the method or methods of distributing the power partly to the new industrial center near the Falls, which, adopting a suggestion of Prof. Forbes, may

be termed Cataract City, and partly to the more distant towns of Buffalo and Tonawanda. Means of utilizing water-power and means of distributing power are well understood by engineers. But the magnitude of the undertaking at Niagara is quite unprecedented, and its success must depend on the application of the highest scientific knowledge and the widest practical experience in the selection of the methods which are at once the most trustworthy and the least costly. It is a governing condition of the problem that the power should be utilized and distributed at a cost permitting its sale at a price which leaves to steam-power no chance of competition. On the other hand, economy cannot in this case be purchased by the adoption of untried or doubtful expedients, and exceptional care must be taken to avoid risk of accident or failure in the supply. If once a manufacturing district is created to apply the power of Niagara, it will become absolutely dependent for its existence on the motors and distributing arrangements, and the effect of a temporary cessation of supply of power would be disastrous.

Nowhere in the world has water-power been so extensively used in manufacturing operations as in the United States. Already, ten years ago, the census returns showed that more than a million horse-power derived from waterfalls were utilized for manufacturing purposes in the United States. Hence it might appear at first sight that all that is required at Niagara is an application on a larger scale of plans already adopted in other localities. In earlier projects for utilizing Niagara this was indeed assumed to be the case. But consideration showed that not only in the dimensions of the machinery and in the magnitude of the power to be handled, the work to be accomplished at Niagara differs essentially from that executed in other localities. Elsewhere, the water-power available is insufficient or only just sufficient for the demand. Generally, it is supplemented by steam-power. Then it is of primary importance that the useful work recovered from the waterfall, under varying conditions of season and fluctuation of trade requirements, should be as great as possible The efficiency of the hydraulic motors must be high, whether worked at full power or not But at Niagara the supply of power is practically limitless. The efficiency of the motors is only so far important as it reduces the cost of the installation of the motors and their adjuncts In the transmission also waste of power is to be measured against the cost of the means of preventing it

A further consideration is this, that, looking to the magnitude of the power to be distributed, the complexity of a system on which many consumers are dependent, and the distance of transmission, there is a probability that the best methods of dealing with the problem are quite different from those already tried in places where these conditions do not exist.

With a very few exceptions, hitherto, where a large water-power has had to be distributed to several consumers, the water itself has been distributed, each consumer having his own hydraulic machinery for utilizing it. In the case of Niagara, the great area which would be occupied by surface canals if this method were adopted, and the great expense of underground excavation in a table-land of rock like that on the American shore of the Falls, would certainly make the cost of the power considerable and would perhaps prohibit its utilization at all. In a very few cases, chiefly in Switzerland, another method has been adopted. The water-power developed on motors, at the most convenient site, is distributed as power to the consumers. Further, in consequence of quite recent developments of mechanical science, steam-power is now, in some cases, distributed to

considerable distances by means of compressed air and electricity. The economy of the production of power at a central station, in these cases, more than counterbalances the cost of the distributing apparatus. In the case of water-power, there is the further advantage that not only is the development of the power on a large scale at a single station cheaper than its development at a number of distant points, but also the cost of air mains or electric conductors may be less than that of the water channels necessary for distributing the water.

If, at Niagara, the simple and well-understood methods of distributing water to consumers, to be utilized by machinery of their own, are to be replaced by methods of distributing power, then the problem at once assumes a character of much greater complexity and novelty. In the distribution of power, by electricity especially, experience is so limited and recent that wide divergences of opinion exist, even on fundamental points, as to the best methods to adopt. During a visit to Europe, in the spring of 1890, the president of the Cataract Company came to the conclusion that it was desirable to bring to bear, on the solution of the problem of utilizing Niagara, the knowledge and experience of many different engineers. It was decided to invite selected engineers or engineering firms to seriously consider the problem, and to send in completely worked-out projects, with drawings and estimates of cost To secure a careful and impartial examination and discussion of these projects the International Niagara Commission was formed A sum of about £4,500 was placed in the hands of the Commission to be awarded, partly in premiums to all invited engineers who sent in plans of sufficient importance, partly in prizes to the plans of greatest merit.

The Commission was constituted as follows

Sir WILLIAM THOMSON, LL D., F. R. S, *President*

Dr. COLEMAN SELLERS, M. I. C E, *Professor of Engineering Practice, Stevens Institute of Technology, Hoboken, N. J., Professor of Mechanics, Franklin Institute of State of Pennsylvania.*

E. MASCART, *Membre de l'Institut, Paris, Professor at the College of France, Director of the Bureau Central Météorologique.*

Col. THEODORE TURRETTINI, Geneva, *President of the City of Geneva, Director of the Works for the Utilization of the Rhone, Director of the Société d' Instruments de Physique.*

Prof. W. C. UNWIN, F. R. S., *Mem. Inst. C. E., Secretary.*

It was arranged that engineers deputed by the Cataract Company should be present at meetings of the Commission.

Preliminary meetings of the Commission were held in London on June 21, 23 and 24, 1890. At these meetings a letter of invitation was drawn up and a list of engineers agreed on to whom the letter of invitation to compete should be sent.

The following are the more important directions laid down in the letter of invitation to competitors, which it is desirable to refer to as an explanation of the action of the Commission.

The purpose of the Company in organizing the Commission was stated to be to ascertain the best system for the enterprise at Niagara and to have the questions involved considered by the highest available scientific authorities.

To place foreign competitors on an equal footing with American competitors, a series of maps, plans, sections and photographs of the locality were prepared and sent with the letter of invitation It was also arranged that traveling expenses should be allowed to such of the foreign competitors as should desire to make a personal examination at Niagara Falls. Two competitors availed themselves of this arrangement for visiting the Falls and consulting the Company's engineers.

The communications to the Commission were to be made in English, and the dimensions on plans and calculations to be expressed in English measures

The Commission was authorized to award the following prizes for the projects which it considered best adapted to the ends of this particular enterprise. Taking into consideration economy of expenditure, convenience of arrangement for progressive enlargement, mechanical results from separate parts, final results per horse-power transmitted, and guarantees of performance

(a) Hydraulic projects for the primary development of power by turbines or other water motors.

1st Prize, £200, 2d Prize, £150

(b) Projects for the transmission and distribution of power from the primary

1st Prize, £200, 2d Prize, £150.

(c) Projects combining both development and transmission—(a) and (b) combined.

1st Prize, £600, 2d Prize, £500

In addition to this the Commission was authorized to pay to each party submitting separate plans of sufficient importance, and accepting and complying with the conditions of the competition

1. £100 to each party submitting one or more projects of (a) and (b)

2. £200 to each party or associated parties submitting projects (c)

Right was reserved to the Commission to withhold all prizes and compensation if in their judgment the projects were undeserving of the same.

The competitors were required to submit in six copies

1. Plans sufficiently detailed to permit an opinion to be formed by the Commission regarding the character of the construction proposed All the special devices for security and regularity, electric, hydraulic, etc, must be shown by separate and descriptive drawings in detail.

2. Explanatory text, giving full information as to the methods proposed, time required for preparation of working drawings and the manufacture of machinery and installation of project, results expected, performance to be guaranteed, commercial values, and with reference in detail to similar installations already constructed, if any, as evidence of practicability and economy.

3. Estimates of cost of furnishing working drawings for manufacture in America of all machinery except pieces requiring special treatment by experienced hands.

4. Estimates of cost of machinery and all accessories, with details thereof, delivered f. o. b. at a port of regular and convenient shipment for New York or Niagara Falls.

The estimates of cost to the Company per horse-power, produced at the point of consumption by the methods proposed, should be made on the assumption that the Company will have expended in the completion of its tunnel, 8,000 feet in length, etc., the sum of $4,000,000; every competitor should add to this sum whatever he might estimate to be the additional cost of his projects.

In calculating the commercial results per horse-power produced, transmitted and distributed by the proposed project, allowance should be made for depreciation and for the service of installation, and in addition 5 per cent interest on the total cost, including the aforesaid sum of $4,000,000.

As to the data on which competitors were required to base their projects, they were directed to assume an unlimited and unfailing supply of water without sediment and a net fall of 140 feet.

Projects were invited for one central station, located at the head of the tunnel, for

1. The development of as much power as the section of the tunnel (490 square feet), the head of water and the hydraulic slope would permit.

2 The transmission and distribution of this power overhead or underground by electricity, compressed air, water, cable or other means to

(a) A manufacturing district built up within a radius of four miles

(b) To the city of Buffalo, distant about twenty miles

The central station should be so designed

1. That a combination of methods of transmission and distribution might be employed according to the probable demand therefor by various classes of industries

2. That a block of 50,000 horse-power might be specially assigned to the Buffalo transmission.

3 That the entire capacity of the tunnel might be developed gradually in blocks of from 10,000 to 20,000 horse-power each.

Lastly, it was directed that, in selecting the methods adopted, attention should be given to the requirements of manufacturing cities, of electricity for domestic, street and manufacturing purposes, water for power, domestic, fire and manufacturing purposes, and air for power, ventilating and refrigerating.

It was arranged that opportunity should be given to all competitors to appear before the Commission to give personal explanation of their projects.

It was at first arranged that the projects should be delivered to the Commission on September 6, 1890 The period allowed for the preparation of projects proved, however, to be insufficient, and the time for sending in projects was extended to the end of the year. Immediately on their receipt, copies of the projects were sent to each Commissioner for consideration.

The Commission met on January 29 for the examination of the projects, conference with the competitors and adjudication of the awards. Meetings of considerable duration were held on January 29, 30, 31, and on February 2, 3 and 4. Messrs. Clemens Herschel and Albert H. Porter, of the Engineers to the Cataract Company, came from the United States to attend the meetings of the Commission.

The projects received were probably as numerous as could be expected, and many of them were worked out with quite extraordinary care and completeness. In some cases the Descriptive Memoir alone formed an extensive treatise and contained information of the greatest scientific value Amongst the projects received there was the greatest variety in the proposals both for developing and transmitting the power. As to the transmission of the power especially, it may be noted that every method known to be available for the transmission of large power to great distances was put forward for adoption in one or more of the designs received. If no project commended itself to the Commission as completely fulfilling all the conditions required, or as suitable for execution without modification, that must be attributed in part to the magnitude and complexity of the problem, and in part also to this further cause.

Several of the competitors proposed to distribute the power electrically, but as to this means of distribution wide differences of opinion still exist. The kind of current used, the potential, the mode of regulation, and the mode of insulation of the conductors, differ greatly in existing installations for electrical distribution It is not yet known what is the practical limit of size of dynamos, and the increase of size involves scientific questions of difficulty. No doubt exists as to the possibility of distributing even so large a power as that at Niagara electrically, but there is room for considerable divergence of opinion as to the methods which are most advantageous and involve least difficulty and inconvenience.

The following is a summary of the projects received by the Commission:

1. *Messrs.* Cuénod, Sautter & Co., *of Geneva, and Messrs.* Faesch & Piccard, *of Geneva.*

Project A.—Complete plans of hydraulic plant for 125,000 horse-power, and of dynamos and electrical distributing arrangements, both for Cataract City and Buffalo. In this project, turbines of 2,500 horse-power drive pairs of dynamos of 1,250 horse-power in underground galleries without intermediate gearing Full details are given of water channels, turbines, dynamos, switch-boards, cut-outs and regulating and safety apparatus.

Project B.—Similar complete plans for turbines and electrical distribution, the dynamos being placed above-ground. The turbines are of 2,500 horse-power, with a vertical shaft driving a dynamo of the same power directly without gearing The plan of distribution is different from that in the preceding project, and a higher potential is adopted in the distribution circuits.

2. *Professor* Vigreux *and* M. Leon Levy, *of Paris.*

Complete plans for 125,000 horse-power. Details of turbines of different types for 5,000 and 10,000 horse-power each. Details of hydraulic governor and sluice gates. Electric arrangements for working sluices. Dynamos of 2,500 horse-power, and 5,000 volts. Power lubricating arrangements, traveling-cranes and ventilating fan. Design of receiving station and dynamo motors. Details of aerial electric conductors.

3. M. Hillairet *and* M. Bouvier, *of Paris.*

Complete plans for hydraulic machines and electrical distribution. Turbines of 10,000 horse-power, driving dynamos of the same power directly, the dynamos being

above-ground and the turbines having vertical shafts. Turbines for actuating regulating sluices of principal turbines. Details of dynamos. Details of dynamo transformers Details of transmission to Buffalo. Plan of distribution in a quarter of the new industrial district. Details of conductors for Buffalo.

4. *Professor* RIEDLER, *of Berlin, and* M. VICTOR POPP, *of Paris.*

Plans of hydraulic machines and air compressors, studied chiefly with respect to transmission of power by compressed air to Buffalo. Details of turbines with horizontal and vertical axis of 5,000 horse-power on the impulse system. Details of outward-flow turbines of 5,000 horse-power. Project I.—Turbines with horizontal axis and underground compressors. Project II.—A similar arrangement with outward-flow turbines at somewhat higher speed, and compressors with slide-valves. Project III—Pressure turbines with vertical shaft driving overground compressors, compressors compound effecting compression in two stages Project IV.—A similar arrangement with impulse turbines. Study of distributing mains for initial air pressures of 86 pounds, 199 pounds and 426 pounds per square inch. Details of experiments on the Paris mains.

5. *Mr.* G. F. DEACON *and Messrs.* SIEMENS BROTHERS, *of London*

Complete project for utilizing 125,000 horse-power and its distribution electrically. Inward-flow turbines of 2,500 horse-power, each driving one series-wound dynamo Dynamos placed in underground galleries. Supply pipes of turbines fed by 5 vertical rock shafts, 12 turbines to each shaft. Dynamos with ring armatures, 400 amperes at 4,500 volts. Conductors, insulated cables laid underground For electric lighting and small motors, potential lowered by motor dynamo transformer Messrs Siemens' project differs from all the other electrical projects in proposing to use constant current and vary the speed and potential of the dynamos.

6. *Mr* H. D. PEARSALL, *of Orpington, England.*

This is a plan for the utilization of 125,000 horse-power by the compression of air in a series of cylinders by the direct action of the water column The engines are a modification of the water ram, compressing and discharging alternately The compressing cylinders or engines, 63 in number, are placed in three tiers in an immense open excavation, each tier using one-third of the fall. The air is compressed to 150 pounds per square inch: each compressing engine is reckoned to give about 2,000 horse-power. A supply of water under pressure is also obtained from the compressing cylinders, amounting to about 150 gallons per horse-power. This would be used for the water supply of the city.

7. *Professor* LUPTON, *of Leeds, and Mr.* STURGEON, *of Chester, England.*

This is a complete arrangement for hydraulic motors and compressed air plant to utilize 125,000 horse-power, and transmit it both to Cataract City and Buffalo. The turbines are inward-flow turbines of 5,000 horse-power each, with vertical axis placed at the bottom of a rock shaft, which serves also as a supply pipe. The water pressure acts below the wheel to support the weight of turbine and shaft. Vertical single-acting air compressors are placed nearly at the ground surface, and are worked from a horizontal shaft driven from the turbine shaft by steel bevel wheels. The air is compressed

to $5\frac{1}{2}$ atmospheres. An air main 10 feet in diameter at Niagara, decreasing to 7 feet at Buffalo, is proposed, with a branch 3-foot main to Tonawanda. The main is laid in a trench, and it is proposed to construct a tramway, worked by compressed air, over it.

Some details of a scheme of electric lighting are given. At Niagara the dynamos of 500 horse-power, at 2,500 volts (alternate current), would be driven by 1,100 horse-power turbines. At Buffalo the dynamos would be driven by compressed-air motors.

Details of head-race canals, sluices, turbines, compressors and air mains are given. A map with proposed distribution of air mains. Also details of the proposed electric stations and turbines.

8. *Messrs.* GANZ & Co, *of Budapest, Hungary*

This is a project for turbines and electric distribution, the latter not fully worked out, for the whole amount of power proposed. Details are given of impulse turbines of 5,000 horse-power each, having vertical shafts to which dynamos are directly attached above-ground. The water is supplied to turbines by a rock shaft. The weight of turbine shaft and armature is supported by a very carefully designed arrangement of suspension bearing, which has been used in similar cases with success The turbines are regulated by relay governors, and details of hydraulic pressure, pumps and accumulators for working the sluices are given

For the electrical distribution, alternate current dynamos, 336 amperes, 10,000 volts are proposed The exciting current is obtained from special continuous current dynamos of 336 amperes at 200 volts. Regulating arrangements by resistances and equalizer are described. The main to Buffalo is proposed to consist of 12 uncovered cables on iron standards 50 meters apart. At Buffalo a station with induction transformers lowering the potential to 2,000 volts It is proposed to use alternate current motors

9. *Messrs* ESCHER, WYSS & Co, *of Zurich, Switzerland*

This is the hydraulic part only of a project for electrical distribution, with some details of a compressed-air plant for part of the power. Details are given of pressure or re-action turbines of 400, 2,500, 5,000 and 10,000 horse-power. For the compressed-air plant a turbine of 2,500 horse-power is proposed, with vertical shaft driving four compressors by mortice-bevel gearing The turbine is regulated by a relay governor acting on a cylindrical sluice on the suction-pipe. The weight of shaft is balanced by water pressure acting on a piston.

For the electrical distribution of 5,000 horse-power turbines are proposed, with vertical shafts The turbines are really double turbines, so placed that the upward pressure on one balances the downward pressure on the other, with a surplus to sustain part of the weight of shaft. The dynamos are attached directly to the top of the vertical shaft.

A second project is given for electrical distribution, in which 12 shafts convey water to pairs of turbines of 10,000 horse-power, together with horizontal shafts coupled directly to a pair of 5,000 horse-power dynamos. A special central shaft accommodates four 400 horse-power and four 100 horse-power turbines, driving pressure pumps and ventilating arrangements. Relay governors control the turbines.

10. *Messrs.* J. J. Rieter & Co., *of Winterthur, Switzerland. Three projects are given.*

Project A. Consists of a group of four pressure or re-action turbines of 2,000 horse-power each, for telodynamic or wire-rope transmission. The turbines have vertical shafts with pivot and hydraulic support. They drive the rope pulleys by bevel gearing Details of intermediate wire-rope station and terminal station for 1,000 horse-power are given.

Project B. Is a design of a group of four pressure or re-action turbines of 2,500 horse-power, with horizontal shafts, arranged to drive dynamos, pumps or air-compressors in underground galleries. There is one water shaft to the group of four turbines and a service shaft for access.

Project C. Is a design for a group of two pressure or re-action turbines of 5,000 horse-power each, with horizontal shafts.

11. *Professor* Vigreux *and* M. Leon Feray, *of Paris*

This is a design for a group of turbines driving pressure pumps for hydraulic distribution of power. A group of outward-flow turbines of 10,000 horse-power drives the pressure pumps Details are given of the regulating, safety and controlling arrangements for the water-pressure system and designs of types of receiving turbines driven by the pressure water.

12. The Pelton Water Wheel Company, *of San Francisco, California.*

Design of a block of 20,000 horse-power distributed thus a 4,000 horse-power Pelton wheel driving service pumps, a 4,000 horse-power Pelton wheel driving power pumps for a system of hydraulic distribution, a 4,000 horse-power Pelton wheel driving air compressors, 4 Pelton wheels of 2,000 horse-power each for driving Ferranti dynamos Details are given of an hydraulic arrangement for working the sluices of a multiple nozzle Pelton wheel, controlled by a governor

13. *Professor* G. Forbes, *of London*

This is a project for the electrical part only of a system of electrical distribution The dynamos are alternate current, working at 500 horse-power and 2,000 volts They have horizontal axes and are placed in subterranean galleries. The electricity is distributed to Cataract City at 2,000 volts, and the larger motors are intended to be synchronizing alternate current motors of the Mordey type, working at that tension. For Buffalo the potential is raised by transformers of 100 horse-power each to 10,000 volts. At Buffalo part of the current may be used for large motors at the full potential. Part is transformed down to 2,000 volts and distributed. A low tension continuous current for lighting and small motors may be obtained by dynamo transformers.

For Cataract City it is proposed that insulated aerial cables should be used. For transmission to Buffalo, bare copper insulated on porcelain and oil, carried on timber trestles.

14. The Norwalk Iron Works Company, *South Norwalk, Conn., U. S. A.*

This is a project for distributing power by compressed air, the compressors being placed underground and driven by Pelton wheels. The compressors are inverted, vertical,

tandem, two stage or compound compressors with Corliss valves and spray injection. Each compressor is 2,500 horse-power, working at 55 revolutions per minute, and compressing 10 atmospheres. For Buffalo five groups of four compressors each are used. Two Pelton wheels drive the group of four compressors coupled directly without gearing. The air main to Buffalo would be 40 inches diameter and the pressure in Buffalo 80 pounds per square inch.

A plan is also suggested for supplying air to Cataract City at 34 pounds pressure by one set of compressors, while a second set taking the air at this pressure would further compress it so as to give a pressure of 80 pounds per square inch in Buffalo.

Some other projects were received, but the Commission considered that either they did not comply with the terms of the letter of invitation or they were of insufficient completeness and importance to permit them to be classed as projects complying with the conditions.

PART II.

DETAILED ABSTRACT OF THE PROJECTS

The history of the origin of the Commission having been given, and a brief statement of its success so far that is indicated by the number of projects received, a somewhat more detailed account of the more important projects may now be attempted. It should, however, be premised that, partly from the haste of preparation, partly no doubt in the case of some European competitors from difficulties of translation into English of memoirs written initially in French, there are a few discrepancies and ambiguities in the papers laid before the Commission which make it difficult to be quite clear as to the meaning intended.

I. *Project of Messrs.* CUÉNOD, SAUTTER & Co., *of Geneva, and Messrs.* FAESCH & PICCARD, *of Geneva.*

These two firms, acting in association, produced two complete projects of similar character for the hydraulic utilization of 125,000 horse-power, and its distribution electrically both to Cataract City and Buffalo. The general features of both projects are the adoption of Girard, or impulse turbines, with complete admission and back vanes, permitting the use of suction pipes, so that the fall below the turbines is not wasted, a unit of power of 2,500 horses for each turbine, as the maximum size which it is practically prudent to construct, and as capable of convenient arrangement to give the speed of rotation most suitable for the dynamos, in the electrical distribution, the adoption of continuous currents at constant potential, on the ground that that method has proved in practice safe, easy and simple. The method of continuous currents is preferred as being simpler, exacting less apparatus, and permitting the attainment of a high efficiency The method of constant potential is preferred to constant current, because on the latter plan the intensity of current would be too great for one circuit, and several circuits would involve complication

In the consideration of the problem of electrical distribution the most fundamental question is the maximum difference of potential which is practically permissible, because the higher the potential the less in general will be the cost of distribution With regard to this Messrs Cuénod & Sautter have assumed that a difference of potential of 10,000 volts between the conductors and earth is not too great to be safely encountered The machines can be adequately insulated by porcelain and oil, and the attendants can be protected by platforms insulated on porcelain and provided with indian-rubber carpets. But in the construction of high potential, continuous-current dynamo machines and motors greater difficulties occur, and here they limit the difference of potential at the terminals to 5,000 volts. They assume that for a rate of work exceeding 50 horse-power motors can be used with a current at 4,500 volts; smaller motors they would limit to 500 volts. As to the next most important question, the greatest power of a single dynamo machine, they have adopted 1,250 horse-power in one project and 2,500 horse-power in the other.

Messrs. Cuénod & Sautter appear first to have designed the arrangement having turbines with horizontal shafts driving dynamos in underground galleries placed a little above the tail-water level. Subsequently they appear to have become dissatisfied with this solution of the problem, and to have designed the arrangement of turbines with vertical shafts and dynamos above-ground.

They pointed out to the Commission that, while from the hydraulic and mechanical point of view the horizontal arrangement was excellent, they had come to doubt whether the rock was solid enough for the construction of such underground galleries as their plan required. These galleries were about 308 feet in length, 79 feet in width and 49 feet in height. Consequently they greatly preferred the arrangement with vertical shafts and dynamos above-ground In this conclusion the Commission fully concurred.

Messrs. Cuénod & Sautter gave, as the reason for preference of the vertical arrangement, merely the doubt as to the stability of the rock galleries. But it is possible that the greater simplicity of the electrical arrangements for distribution, in the second project, had also some weight in the decision.

Messrs. Cuénod & Sautter adopt multipolar dynamos, though, at first sight, it might be alleged that bipolar machines would be less complicated, have less loss from hysteresis, require less expenditure of current in excitation, and waste less in Foucault currents. As to hysteresis, they urge that though in multipolar machines the number of cycles is increased, the mass of iron in motion is diminished, while the cooling surface is greater, ventilation more perfect, and speed of rotation less. The importance of the Foucault currents is diminished because the moving mass of copper is much less than in bipolar machines, and it can be sub-divided without seriously increasing internal resistance. As to the current for excitation, it is so small as to be of little consequence Two types of dynamos are given One of 1,250 horse-power, with a horizontal axis, is a Gramme ring machine of great diameter, provided with a double field of ten poles, arranged so that internal and external poles are utilized. The part of the conductor on the lateral faces consists of plates insulated by air and forming a ventilator. The machine virtually consists of five bipolar machines, each of 250 horse-power—a very advantageous size for a bipolar machine.

The second type of dynamo with vertical axis is of 2,500 horse-power. The mean velocity of the armature is 126 feet per second. This is, in their opinion, too great a speed to permit the use of magnetic masses, transmitting the lines of force in the ordinary way, and an ordinary armature would also have been too heavy.

A lower speed would have been unsuitable for the turbines. Hence a special type of armature was designed which they consider to have these advantages the hysteresis and Foucault currents are diminished, the lines of force traverse the mass radially so that their density is decreased, the thickness is reduced to that necessary for strength and mechanical solidity, the mass of iron is diminished to one-fourth or one-fifth of that in an armature of ordinary construction, the iron plays only the part of a mechanical support for the winding, destitute of appreciable magnetic resistance; the winding adopted permits a great reduction of the exterior wire subject to centrifugal force, the commutator is of the same diameter as the ring, an arrangement which, though costly, permits perfect regulation of the brushes and avoidance of sparking, the regulation of the brushes is effected automatically.

For the regulation of the machines generally, and particularly to secure a constant e m. f., the following means are adopted: (1) There are relay governors of an extremely excellent type controlling the speed of the turbines. (2) Fly-wheels are placed on each dynamo shaft, the inertia of which, added to that of the armature, moderates the rate of change of speed and gives the turbine governors time to effect an adjustment. (3) There are automatic electric regulators effecting, through greatly subdivided

resistances, a regulation of the exciting currents of the field magnets. The control of the e. m. f. is effected by these regulators quite independently of any supervision by the staff of attendants. In case of failure of these automatic regulators, there would still be no great variation of e. m. f., because the dynamos have little internal resistance, the resistance of the external circuit is small, the fluctuation of speed is moderated by the fly-wheels, and the turbine governors act promptly.

For conductors aerial lines are advocated, placed at such an elevation as to clear houses and trees. Where aerial lines are impossible culverts are recommended, the insulation still depending on porcelain and air Subterranean insulated cables are, in the opinion of Messrs. Cuénod, Sautter & Co, too costly.

PROJECT A. *Hydraulic Machines.* In this design there are 55 turbines, each of 2,500 horse-power, in 5 groups Each turbine drives 2 dynamos, the turbine shaft and dynamo shaft being connected by Raffard couplings, which are both elastic and insulating The turbines are impulse turbines, but by a well-known modification they are capable of working as pressure turbines also, and consequently suction pipes can be applied to utilize the head below the turbine house floor

The head-race channel has five branches, one to each turbine chamber, and is furnished with surface screen, movable dam or sluice to each branch grating, and electric automatic balanced sluices, which in case of accident can be closed from the galleries below. Each of the five turbine galleries is in communication with the surface by a wide service shaft, with staircase and lift, traveling-crane, warming and ventilating apparatus The electric automatic sluices would shut off water from the chamber in case of accident, and besides this there is a butterfly valve worked by pressure water (300 pounds per square inch) provided for working also the relay turbine governors A shaft in the floor to the tail-race, covered by a balanced platform which opens under a pressure of 6 inches of head, serves to discharge from the chamber any water entering if an accident occurs. The turbine shaft bearings are self-lubricating, and act also as thrust bearings. The turbines run at 180 revolutions and are provided with two fly-wheels The total cost of excavations, tail-race tunnel, turbines, accessories, interest, depreciation and maintenance, is estimated to be $6 10 per effective horse-power delivered to dynamos.

Electrical Arrangements. There are 100 dynamos, each of 1,250 horse-power, at 180 revolutions per minute, and 10 reserve dynamos. For the new Cataract City, three galleries with 60 dynamos coupled in series in pairs, so as to give a total resultant e m f. between the extreme conductors of 3,000 volts, are allotted. The distribution to Cataract City is in two circuits of 1,000 volts for the larger motor and two circuits of 500 volts for the smaller motors, electric lighting, tramways, etc

Each turbine of 2,500 horse-power drives 2 dynamos coupled in series, giving 1,650 amperes at 1,060 volts. Hence the 20 dynamos in each gallery give 16,500 amperes at 1,060 volts. Each series of 10 dynamos is coupled in tension with an intermediate or neutral conductor. Two galleries feed the two 1,000 volt circuits. In the central gallery of the three, this neutral conductor is prolonged to form the two 500 volt circuits.

The neutral conductor is connected to earth. Hence the greatest difference of potential of any part of the system and the earth cannot exceed 1,500 volts, while the extreme difference of potential between two circuits is 3,000 volts. The distribution network, which is proposed to be carried on high masts, with oil insulation, is estimated

to require 1,000 tons of copper. From the large section of the conductor the spans may reach 200 yards.

Of the whole energy of the turbines 5 per cent. is reckoned as the loss in the primary dynamo generators, 5 per cent. in the circuits, 5 to 15 per cent. in the motors. The average efficiency is then about 80 per cent.

Taking the proportion of the excavation and hydraulic machinery, adding the cost of electric plant and allowing for interest, depreciation and supervision, the cost per effective horse-power distributed in Cataract City is estimated at $11.28 per annum.

Buffalo Transmission. The two remaining galleries (allotted to the Buffalo transmission) have dynamos of 1,250 horse-power, giving 544 amperes at 1,600 volts. Ten of these are coupled in series for each circuit, giving a current of 544 amperes at 16,000 volts. There are four such circuits to Buffalo. Two central stations are arranged for in Buffalo, in each of which there are two series of motors driving secondary dynamo generators, which transform the current down to the potential required for distribution. The mode of distribution is similar to that in Cataract City—four circuits, two at 1,000 and two at 500 volts, with a neutral wire.

The loss on the primary dynamo generators is reckoned at 5 per cent.; the loss in transmission to Buffalo 5 3 per cent., 10 per cent. is lost on the dynamo transformers of the Buffalo secondary station, adding now 5 per cent. loss for the circuits in Buffalo and 10 per cent. for the motors, the total loss is 35.3, and the resultant efficiency is about 62 per cent.

Adding the cost of the proportion of the hydraulic construction involved to the electrical plan, and allowing for interest, depreciation and supervision, the cost per effective horse-power distributed in Buffalo is estimated at $20.13 per annum.

PROJECT B. *Hydraulic Machinery.* The turbines are impulse turbines with suction pipes and vertical axis. Each turbine is of 2,500 horse-power, at 136 revolutions per minute. There are 50 turbines for regular work and 6 in reserve, in two parallel groups of 28 each. The dynamos are above-ground, one on each turbine shaft, in a large horseshoe building. The head-race enters between the wings forming the sides of the horseshoe. The lateral channels are grouped in pairs, and are each provided with a surface screen, grating and sluices. From the lateral canals wrought-iron supply pipes, 67 inches in diameter, lead to the turbines below Each turbine is thus independent, and this is, in Messrs. Faesch & Piccard's opinion, of more importance than the economy which might be obtained by grouping the turbines in pairs or fours with one supply pipe Four shafts with staircases and traveling-cranes lead from the dynamo house to the turbine galleries below. There are traveling-cranes also in the turbine galleries. The vertical shafts of the turbines are tubular, to reduce weight and to gain stiffness enough to dispense with intermediate journal supports. To carry the weight of the turbine, with its vertical shaft and fly-wheel (of 12 tons), amounting altogether to a weight of 35 tons, a cylinder and piston is formed in the turbine case. The water pressure, under a head of 105½ feet, acting on the under side of this piston, supports the weight of the turbine and its attachments. As an additional precaution a collar-thrust bearing is also introduced near the top of the shaft. This has automatic lubrication. Above the fly-wheel is a Raffard coupling connecting the shaft with the armature of the dynamo. The turbine can easily be dismounted, if necessary, by the two traveling-cranes. The relay governor to each turbine is of the same excellent type as that in the horizontal arrangement.

Messrs. Faesch & Piccard guarantee that with this governor the variations of speed in ordinary work would not exceed 1 per cent. The sluices for regulating the turbines are cylindrical sluices on the suction pipes, a very satisfactory arrangement, because the sluices are completely balanced with respect to the water pressure. These sluices are worked by hydraulic pressure under the control of the governors. Small turbines and pumps, and an accumulator in a special chamber, give the supply of water, under a pressure of 300 pounds per square inch, for working the regulating sluices.

Electrical Arrangements. The dynamo is arranged with an armature having very little iron. It revolves between field magnets having contrary poles opposite. The iron of the armature then only serves as a support for the winding, and reduces the magnetic resistance in the space between the poles of the field magnets. The winding is of a special type, derived from the drum winding, without its inconveniences. There are twenty-two magnetic circuits, each formed by an exterior field magnet and two interior half magnets. The lines of force form a simple circuit, crossing the armature twice radially. The armature can be withdrawn by cranes without disturbing the field magnets The commutator has a diameter equal to that of the armature. The dynamo is insulated by porcelain, oil and insulating cement. The Raffard coupling insulates it from the shaft. The exciting current of the field magnets is regulated by resistances controlled by hand or automatically Each gallery contains 28 dynamos—four of 530 volts, and twenty-four of 4,735 volts Of the dynamos in each gallery, with the larger potential, 12 are regulated by hand only—8 for the Cataract City circuits, and 4 for the Buffalo circuits are regulated automatically. The dynamos of 530 volts are all regulated automatically.

Method of Distribution The distribution is arranged thus · The new industrial center, or Cataract City, is supplied by five conductors, forming four circuits, two at 2,500 volts, two at 500 volts, and a neutral wire which is connected to earth. For Buffalo, there are two conductors at 4,500 volts, and a neutral wire leading from Niagara Falls to Buffalo. At Buffalo the distribution circuits are reconstituted by compensating machines. A group of compensating machines consists of three machines, capable of acting as generators or motors, and coupled by Raffard couplings so as to run at the same speed.

If the current is equally divided amongst the three machines they have no action If one circuit is overloaded, the potential falls and the automatic regulator increases the magnetic field of the machine, so that it acts as a secondary generator, being driven by the two other machines acting as motors. Thus, in Buffalo two distinct networks of four conductors are supplied. These give in each network two circuits of 2,500 volts, one of 500 volts, and a neutral wire.

The efficiency of the generating dynamos is 95 per cent. The loss in the network in Cataract City is 1 7 per cent. The efficiency of the motors may be taken at 80 per cent Hence the resultant efficiency of the system is 84 per cent.

The efficiency in the Buffalo distribution, allowing for the loss in the compensating groups, is estimated at 79 per cent.

The annual cost is estimated as follows: For Cataract City the cost of the excavations, tail-race and turbines, allowing for interest, depreciation and supervision, comes to $5.76 per effective horse-power per annum. The electric plant and conductors, with similar

allowance for interest, depreciation and supervision, cost $4 12 per effective horse-power per annum. Hence, the total cost is $9 88 per effective horse-power distributed per annum.

For Buffalo the cost comes to $12.70 per effective horse-power distributed per annum.

It should be stated that the project of Messrs Cuénod, Sautter & Co. and Messrs. Faesch & Piccard is elaborated with great care. The memoir is carefully reasoned, the drawings are complete, even as to details. The Commission approved of the hydraulic arrangements, giving the preference to the vertical arrangement. They noted especially the excellence of the governor for regulating the turbines, which has proved to be thoroughly efficient in practice, and the system of using a fly-wheel to moderate the rate of change of speed and give time for the action of the regulating sluices. On the other hand, they were not of opinion that a case had been made out for so wide a departure from well-known and well-tried forms in the dynamo proposed, and they did not consider that the mode of carrying the conductors of the distribution circuits had been sufficiently studied.

II. *Project of Professor* VIGREUX *and* M. LEON LEVY, *of Paris*

These competitors submitted a very elaborate memoir and very complete portfolio of drawings. The dynamos proposed being of 2,500 horse-power, the machinery is arranged in groups of four dynamos, driven by turbines of 10,000 total horse-power

Hydraulic Machinery. Design A. Group of four axial-flow pressure turbines of 2,500 horse-power each. The turbines have horizontal axes, and are coupled in pairs to balance the axial water pressure, and driving a dynamo on either side at 300 revolutions. There are thus altogether four turbines and four dynamos in underground chambers. The turbines have suction pipes, and their efficiency in ordinary work is reckoned at 70 per cent. A short supply pipe 8′ 6″ in diameter, leading from a vertical rock shaft, feeds the group of turbines.

Design B Group of two inward-flow pressure turbines of 5,000 horse-power each, with horizontal axis, each turbine driving a dynamo on either side. The other arrangements are similar to those of the axial-flow turbine. The flow being radial, each turbine can be constructed so that the water pressures are balanced, and the inward-flow turbine has the advantage of greater steadiness of speed

Design C Group of four outward-flow pressure turbines placed opposite in pairs, but not coupled axially. Efficiency the same and supply arrangements similar to those in the preceding designs.

For all these systems of turbines, relay governors are provided. An ordinary pendulum governor acts on the distributing valve of an hydraulic cylinder worked by the pressure of the head which drives the turbines. The piston is fixed and the cylinder moves under the action of water admitted by the distributing valve to either end. A rack on the cylinder, acting on a toothed sector, rotates an ordinary disc or throttle-valve in the turbine supply-pipe. It may in passing be doubted whether an enormous disc valve of the kind here shown is really safe, and also that such a valve is far from being a balanced valve. The force required to move it would be very considerable with the high velocities which Professor Vigreux and M. Levy allow in the supply-pipes.

For 120,000 horse-power, 12 groups of turbines of either of the types described are required. Eleven of these are allotted to the production of a high-tension current and

one to produce a low-tension current for lighting the works, for exciting the field magnets of the other dynamos and for other subsidiary purposes. Two reserve groups are also proposed, one for high tension, one for low tension, in case of accident to any other group.

The head-race has a lateral bay to each of the fourteen vertical water shafts, and this is provided with strainer and sluices. The sluices consist of a series of butterfly valves in a vertical frame, and arrangements are provided for working these by hand winches or by a small electric motor.

Organization of the Works. The works are excavated in the rock, and comprise a gallery 868 feet in length by 112 feet in width, divided longitudinally into three bays by two parallel rows of piers. The roof of the gallery is formed by segmental vaulting. The center bay contains the turbines and shafts to the tail-race, to discharge water if an accident happens. Each lateral bay contains 28 dynamos. Service shafts, 18 feet in diameter, with electric lifts, are provided. There are ventilating shafts, and a special shaft for the electric cables. The ventilating fan is driven by an electric motor, and is capable of completely changing the air in the galleries in two hours. A tram line circulates round the dynamo galleries, and each gallery is provided with electric traveling-cranes. Continuous lubrication is provided for by oil pumps, worked by power. The galleries are nearly the same whichever of the three types of turbine is adopted, but the inward-flow turbines have the advantage of some economy of cost, the outward-flow the advantage that each turbine and dynamo is independent of the others in the group.

The cost of an effective horse-power, obtained on the turbine shaft, allowing interest, cost of excavation, and machinery, etc., depreciation and supervision, is estimated at $3 per annum

The Electrical Arrangements. Continuous current is selected as alone answering the various requirements of lighting and power, and permitting the use of accumulators. The highest potential is fixed at 5,000 volts. Greater tensions were actually used in the Creil experiments, but the tension selected is judged to be safer and more practical by M Levy.

The dynamos of the generating station are divided into groups, according to the different localities to be served, and those of each group coupled in quantity. Any dynamo, however, can be placed on any service.

Each group is connected to the district served by virtually a single conductor, with a return conductor. Thus for Buffalo there may be several cables, but these would be combined so as to form a single conductor to, and return conductor from, Buffalo The advantage is that the conductor can be increased at any time without disturbing any of the established distributing arrangements.

At the district served the conductor will branch into as many conductors as there are receiving and transforming stations. The potential being kept constant at the regulating point from which the conductors branch, each station will be independent, and regulate itself according to its requirements. A control line of telegraph wire from the regulating point to the generating station allows the potential to be known, and the generating dynamos to be regulated as required.

The efficiency of the line to Buffalo is fixed at 85 per cent., so that the potential at the regulating point in Buffalo would be 4,250 volts. The efficiency of the whole

electric system to Buffalo is estimated at 68.85 per cent. for high-tension currents, and 62 per cent. if the current is transformed to a low-tension current. For Cataract City the efficiency would be higher, probably 72 to 76 per cent. The advantage of the system adopted is, that the operations of distribution are identical with those now employed for low-tension currents.

Dynamos. These are of 2,500 horse-power, 330 amperes and 5,000 volts. This moderate power facilities the adjustment of the plant to work in different localities during the progressive growth of the installation The machine has two armatures of the Gramme ring type, because it is difficult to obtain more than 3,000 volts with one ring. The dynamo is multipolar, with six field magnets, and excited by a separate low-tension current. The mechanical construction is stated to be simple and easy to execute; no cast-iron is used on moving parts, and the machine easily divides for inspection.

Four similar machines, differently wound, are allotted to provide the exciting current at 500 volts. In connection with the exciting current it is proposed to use accumulators as an adjunct.

A liquid rheostat is employed to close or open the circuits.

The switchboards and the safety, regulating and other contrivances are fully described in M. Levy's memoir.

Primary Distributing Conductors. The distribution to Buffalo is taken as a type of the methods to be adopted. Insulated cables are rejected as too costly, and as imperfectly insuring safety. Naked copper on insulators is selected, carried overhead where that is possible, and in culverts where necessary. For Buffalo, five bars, each 4 6 square inches in section, form the outgoing, and a similar number the return line. These are carried on porcelain insulators. Flexible strips at intervals permit expansion Culverts would be of concrete.

For the overhead conductors a novel arrangement is proposed. Four lines of iron-braced girders of 100 yards span are used, carried on trestles. Each girder acts both as support and conductor. The girder is equivalent in conductivity to one copper strip. Three copper strips are placed on it. The successive girders are connected by arched copper strips, permitting expansion. Each girder end rests on a wood block, supported by four porcelain insulators. These rest in a cup containing petroleum.

For a short transmission from the generating works overhead insulated cables may be used.

Receiving Dynamos or Motors. These are similar in construction to the generating dynamos, a liquid rheostat is used for making and breaking circuit. A separate exciting machine, driven by the receiving machine, is used. For starting, the current will be obtained from accumulators.

Transforming Machines. A receiving machine drives a dynamo at low tension. The machines are similar, but with different winding. Raffard's coupling is used for powers not exceeding 200 horse-power. Any mode of distribution may be adopted for the low-tension current. With good machines in full work the efficiency of a transforming group may be 80 per cent. In the least favorable case it is 65 per cent.

Another mode of transformation is to charge accumulators in series, and discharge them separately. M. Levy believes accumulators to be efficient, practical and economical.

The total cost per effective horse-power distributed, including interest on tunnel, excavation, hydraulic and electric plant, depreciation and supervision, is estimated at $23.60 per annum.

The Commission were not generally in favor of the underground position of the dynamos proposed. Consequently both the turbines and dynamos, with horizontal axes, should in their view be replaced by a different arrangement. The system of overhead conductors to Buffalo did not seem to them a desirable one, and they doubted the advisability of using accumulator batteries to excite the field magnets.

III. *Project of* M. HILLAIRET *and* M. BOUVIER, *of Paris.*

This is a complete project for hydraulic utilization and electrical distribution of 125,000 horse-power, with a very careful memoir and very beautiful and detailed drawings.

Hydraulic Machines. Thirteen turbines of 10,000 horse-power each are proposed, each working a single dynamo placed above-ground. The turbines have vertical shafts driving the dynamos directly. The turbines are impulse turbines with partial admission, consequently suction pipes cannot be used, and a portion of the fall below the turbines is necessarily wasted. They are arranged for the exceptionally low speed of 80 revolutions per minute. For each turbine two vertical shafts are sunk through the rock, one serving as a supply pipe and the other as a shaft for access and containing the turbine driving shaft. The head-race is also separated into separate channels, one to each turbine.

The object is to facilitate progressive development of the power and to secure independence of each turbine Strainers and sluices, and somewhat elaborate arrangements for cleaning the strainers and removing the rubbish, are provided The turbine shaft is made hollow, with solid steel journals at intervals The weight is supported on a pivot partly on an hydraulic piston The turbine is entirely constructed of steel plates and wrought iron The turbine is regulated by a series of small sluices closing successively the guide blade channels, a method conducing to efficiency when the turbine is not working at full power. In the present case that is not a matter of much importance, but no doubt in other respects this mode of regulation has advantages The regulating sluices to the guide blades are driven by small special turbines. The shaft journals are continuously lubricated by oil pumps.

Electrical Arrangements. The dynamos are all identical, and can be disposed to supply either Buffalo or Cataract City. The dynamos of 10,000 horse-power are placed above-ground, the excavation being reduced to a minimum, and the plan of subterranean galleries is rejected. Calculation shows, in M. Hillairet's opinion, that the plan of turbines with vertical shafts is safe and economical.

The method of distribution is different in Cataract City from that in Buffalo. In Cataract City the receiving motors are in parallel arc, in Buffalo in series, each taking the total current. The generating dynamos are in series, a variable number supplying Buffalo, according to requirement, and a fixed number Cataract City. The receiving motors transform energy at high potential into energy at a potential convenient for distribution in a restricted area.

Each dynamo gives a maximum difference of potential at the terminals of 1,000 volts and an intensity of 7,000 amperes. So large a dynamo could not be constructed with an

armature having an iron core. But it is possible if the armature circuits are purely electro-dynamic. The dynamo has 16 field magnets, in four groups of four, constituting a dynamo of eight poles. The armature consists of vertical laminæ disposed as generators of a cylindrical surface, concentric with the axis of rotation. They are fixed by insulated bolts to a disc or wheel, and have a velocity of 98 feet per second. Ordinary materials so placed would be incapable of resisting the centrifugal force, and M Hillairet proposes to use aluminum bronze with a density less than three, and which having to resist a stress not exceeding 5,000 pounds per square inch has an ultimate strength of 37,000 pounds per square inch. The field magnets are of cast-iron, with pyramidal pole pieces of wrought-iron, having poles much smaller than the body of the magnets. There are 32 brushes connected in series, and therefore, each conducting the total current.

Motor Transformers at Buffalo. M. Hillairet does not consider it prudent or practical to work private installations at the full potential of the line to Buffalo. Hence the energy distributed must be transformed to a lower potential. The type of receiving machine chosen is of 2,000 horse-power taking a current of 7,000 amperes and acting with a difference of potential of 200 volts at its terminals. The axis is horizontal. The armature is similar to that described above. The speed, 300 revolutions. There are four poles or four fields of induction. This motor might drive a low-tension dynamo, but a simplification is possible. When the induced bars of the armature pass through a polar interval they are inactive. They are out of circuit for about a quarter of a turn. If between the four groups of field magnets four other inductors are placed, excited by the total current, the armature bars will suffer an induction as they pass. By adding new polar pieces and brushes connected in series a complete circuit is established, in which an electromotive force is generated which can be utilized for distribution. To secure constancy of potential a centrifugal governor is used which, acting on a variable shunt, modifies the field of the primary circuit if the speed varies. Such a solution would be impossible with ordinary machines with magnetic material in the armature. The motive and resisting efforts in the motor transformer proposed are confined to the periphery of the armature and produce no torque on the shaft It is proposed to make the field magnets of soft cast-steel, as cast-iron field magnets would have occupied too much space.

Mains to Buffalo. The conductors are to be copper, in culverts. Four bars are required for Buffalo, connected in pairs in quantity and forming an outgoing and return conductor, each of 7¾ square inches in section. These are carried on porcelain insulators.

Distribution in Cataract City. The problem is to supply a large number of motors, the work of which varies, and which are of comparatively small power. Below 1,000 horse-power the type of dynamo described above is abandoned, and the machines ordinarily used for continuous currents adopted. For two miles round the generating station the current would be distributed directly to motors of not less than 25 horse-power at a tension at the terminals not exceeding 1,000 volts. Between two miles and four miles the current from two dynamos in series would be distributed to motors of not less than 50 horse-power with a tension of 2,000 volts at the terminals of the

distribution. For smaller motors, motor transformers would be established at various points of 300 horse-power, giving currents of 100 or 200 volts.

The electric mains would be subterranean wherever possible. Aerial distribution would only be adopted very exceptionally. All distributing centers would be connected telephonically with the generating station.

The Commission considered that there was much of high merit in the hydraulic part of M.M. Hillairet & Bouvier's project. But they thought the regulating sluices of the turbine too complicated and the turbine itself built up of too many pieces. They objected to the tubular shaft with intermediate solid journals, and considered objectionable the adoption of a type of turbine with partial admission, and therefore without suction pipes, involving a loss of head.

The most interesting point in this turbine is its low speed rotation. But they were of opinion that it should not be supposed that any limitation of absolute or rotational speed is required on account of electrical conditions. With respect to the peculiar dynamo adopted they thought that a necessity had not been established for so great a departure from ordinary types.

IV. *Project of* M. Victor Popp, *of Paris, and Professor* A. Riedler, *of Berlin*

This is a project for the utilization of the water-power by turbines and its transmission by compressed air. Since the greatest doubt would attach, in such a project, to the question of the transmission by compressed air to so great a distance as Buffalo, or, at the least, it is in the proposal to use compressed air for transmission to so great a distance that past experience is chiefly overstepped, M Popp and Professor Riedler have chiefly applied themselves to the explanation of this part of the Niagara problem It may be conceded at once that compressed air has this advantage that, supposing it possible to convey it from Niagara to Buffalo without too great cost or loss, then it could be used at once in place of steam in existing motors with the minimum of disturbance of existing plant The project is based partly on experience gained in working the compressed-air plant in Paris, partly on special experiments carried out by Professor Riedler.

M. Popp and Professor Riedler insist strenuously on this point—that a compressed-air scheme of transmission can be based absolutely on experience. Nothing need be new or untried in the machinery, or even of exceptional dimensions. As to the air main, its construction involves well-known expedients only, and its efficiency can be estimated from accurately-observed data. On the other hand, they contend that at present any electrical scheme of this magnitude must involve large elements of uncertainty, both as to efficiency and cost.

They claim that their project is in accordance with the following statement:

(1) One effective horse-power at the central station is assumed to compress 380 cubic feet of air per hour to 120 pounds per square inch (above atmospheric pressure). In Paris as much as 425 cubic feet per hour have been so compressed per horse-power, even with imperfect engines.

(2) It is proposed only to use moderate pressures of six or eight atmospheres, although pressures up to thirty to fifty atmospheres have been practically used.

(3) The estimate of the loss in the Buffalo main is based on data obtained in the complicated and imperfect mains of Paris, although there are causes of loss in the latter case which would be absent in the former.

(4) The consumption of air in the engines at Buffalo is assumed to be the same as in old steam-engines in Paris, and no allowance is made for the economy which would result from using more perfect appliances.

(5) The cost is estimated on a sound commercial basis.

Turbines and Compressors for 5,000 *Horse-power.* The most advantageous unit of power, permitting gradual extension, is taken to be 5,000 horse-power. Underground compressors permit the simplest arrangement, and are least costly. Compressors above-ground are more accessible and can be better attended to

For air compressors, piston speeds up to 1,000 feet per minute are unobjectionable But the number of rotations should not much exceed 80 per minute; in air compressors with slide valves 150 revolutions per minute might be obtained. But to secure trustworthiness, M. Popp and Professor Riedler prefer 80 revolutions, both for compressors and turbines. Each turbine shaft drives a compressor having two low-pressure and one high-pressure cylinder. Such compressors would be smaller than many existing blowing engines working at the same pressures

For projects A and C, turbines of Messrs. Rieter, of Winterthur, are adopted The turbines are simple and accessible for repair They are axial-flow pressure turbines (with suction pipes) of 5,000 horse-power each, arranged with a horizontal shaft in Project A, and a vertical shaft in Project C, the vertical shaft is hollow, and its weight is balanced by the pressure on a piston formed in the turbine case. The turbines are of a diameter less than that for which the efficiency would be greatest. Hence the efficiency is assumed at 60 per cent. only. Each turbine is controlled by a disc throttle valve and relay governor.

For Project B an outward-flow pressure turbine, with vertical axis, designed by Messrs. Nagel & Kaemp, of Hamburg, is adopted. The water enters the turbine below, and its upward pressure balances weight of turbine and shaft, without any special device. The turbines are so placed as not to require suction pipes The same turbines, but with horizontal axis, are shown driving high-speed compressors.

For supplying water to the turbines vertical rock shafts are proposed, and by preference one water shaft should supply two turbines. A group of five 5,000 horse-power turbines is proposed, with two smaller auxiliary turbines of 2,000 horse-power. The large turbines would not be worked below 3,000 horse-power. The regulation would thus be more efficient. The small turbines would be regulated automatically by the pressure in the air main.

Project A. *Rieter Turbines, with Horizontal Axis and Underground Compressors at* 80 *revolutions.* Turbines in pairs in a rock gallery 53 feet wide. Horizontal turbine shaft prolonged either way to form a three-throw crank shaft driving three compressing cylinders. The compressors are Riedler compressors with controlled valves.

Project B. *Nagel & Kaemp Turbines, with Underground Compressors at* 150 *revolutions.* The compressors have oscillating slide valves, the suction and delivery valves separate with positive gearing. M. Popp and Professor Riedler consider Project A

preferable, the efficiency in Project B not being much greater, the expense not much less, and the wear and tear more serious.

PROJECT C. *Nagel & Kaemp Turbines and Overground Compressors at* 80 *revolutions.* Three turbines are supplied from one vertical water shaft. The vertical turbine shaft is coupled to a two-throw crank shaft. Two compressor cylinders are placed below, driven from one crank-pin, and another above. The driving is virtually the same as with three cranks at 120°. A small fly-wheel is used, 8½ tons weight.

PROJECT D. A similar arrangement with Rieter turbines.

Air Main to Buffalo. An opinion is expressed, based on Paris experience, that no air reservoir is required The pressure of compression is assumed at eight atmospheres, giving six atmospheres in Buffalo, so that air engines will work under the same conditions as in Paris. Messrs. Popp and Riedler give details of a series of experiments on the leakage and resistance of the Paris mains, on which they base their calculations of the size and loss of pressure in the main to Buffalo They believe that the loss by leakage may be guaranteed not to exceed 2 per cent. It is not clear what is the length of main to which this estimate applies. They assume the frictional resistance at 1 2 pounds per square inch, per mile of main, with a mean velocity of the air of 34 feet per second.

Thus if 25,000 horse-power is transmitted to Buffalo by air compressed at Niagara to 114 pounds per square inch, giving 88 pounds per square inch at Buffalo, through two mains, two and one-half feet in diameter, they estimate the loss due to friction at 11 per cent. of the power developed at Niagara.

If 75,000 horse-power is transmitted to Buffalo by air compressed initially to 199 pounds, giving 110 pounds per square inch in Buffalo, they estimate the frictional loss in the same mains at 18½ per cent. of the power developed at Niagara. The mains need only be one-quarter inch thick.

Supposing the same mains increased to three-eighths inch thick, then they estimate that 125,000 horse-power could be transmitted to Buffalo, the air having an initial pressure of 285 pounds per square inch, a pressure at Buffalo of 175 pounds per square inch, and a mean velocity of 55 feet per second They point out that the amount of power transmitted could thus be increased from 25,000 to 125,000 horse-power without alteration of the mains. For the higher pressures, however, a fourth compressing cylinder would have to be added to the compressors.

If a higher pressure is chosen then the cost of installation can be diminished. They estimate that, with an initial pressure of 426 pounds per square inch at Niagara, and a double main of only one foot diameter, 25,000 horse-power can be transmitted to Buffalo with a loss of 200 pounds per square inch. A series of detailed calculations of different mains are given.

Compressors. In the memoir of M. Popp and Professor Riedler a careful examination is made of the efficiency of compressors, and the results of experiments on various compressors at Paris are given. It is well known that in many cases the efficiency of compressors is low. In some mining installations the waste of work in the compressor amounts to four-fifths of the energy expended. This loss is chiefly due to useless heating of the air. Experiments on several of the compressors at Paris showed that the work wasted amounted to 40 to 100 per cent. of the useful work done; or to put it in the more usual way, the ratio of useful work of compression to work expended was only 71 to 50

per cent. The later compressors at Paris have been on the Riedler system, with two-stage compression and controlled valves. With the compressors previously in use, from 261 to 305 cubic feet of air were compressed to six atmospheres per indicated horse-power per hour. With the new Riedler compressors 354 to 384 cubic feet were similarly compressed per indicated horse-power per hour.*

Utilization of the Compressed Air. Compressed air may be applied to lifting loads, forcing liquids, transporting grain or sand. For lifts it may be used acting on a water column. Air motors are in use in Paris, of power ranging from one-eighth horse-power to 150 horse-power. The expense of installation of an air motor is about two-thirds of that of a steam-engine and boiler. All existing engines can be transformed into air engines almost without alteration, and without interrupting the ordinary service. Old steam-engines are working in Paris with a consumption of 450 cubic feet of air per hour, at five atmospheres per effective horse-power.

Taking the efficiency of the compressors to be such that they give 380 cubic feet at eight atmospheres per effective horse-power per hour, the combined efficiency of compressors and motors is estimated at 85 per cent., every loss from Niagara to Buffalo included.

By reheating the air before use a further advantage is gained, and it is stated that the heat so expended is applied five times more efficiently than if used in generating steam.

Cost of an Effective Horse-power in Buffalo. Taking a 25,000 horse-power plant, and assuming a loss by leakage of 5 per cent., and that 380 cubic feet compressed require one horse-power at Niagara and 450 cubic feet give one horse-power at Buffalo, then 25,000 horse-power at Niagara will give 20,000 effective horse-power in Buffalo. Each horse-power then is estimated to cost $6.50 per annum in Buffalo, or, allowing for depreciation, $12.05. With a larger transmission the cost per horse-power would be less.

Apparently the estimate above does not include interest on cost of installation. If 5 per cent. is allowed as interest, then the cost per horse-power distributed in Buffalo, allowing for interest, depreciation and supervision, is $31.25 per annum.

The project of Messrs. Popp and Riedler is very carefully studied. Their claim, so far as it has anything of novelty, rests chiefly on the assumptions that a much higher efficiency can be obtained in compressors than has been usual hitherto, and that the loss in the mains is less than it has generally been estimated. As to the compressors, there is no doubt that the two-stage compression, with intermediate cooling between low and high-pressure cylinders does secure a very high efficiency, and the special controlled valves of Professor Riedler are excellent in diminishing the loss of work due to ordinary valves and securing perfect quietness of action. As to the loss in the mains, it should be pointed out that the special researches in Paris are of the highest value as an addition to the scientific knowledge of air friction. For pressures not exceeding those in Paris the estimate of the frictional loss cannot be much in error, and, indeed, does not differ much from an estimate based on earlier experiments. In deducing the friction at higher pressures, Messrs. Riedler and Popp have no equally satisfactory experimental basis, and the friction at these higher pressures will probably be greater than they have calculated.

* The volumes mentioned throughout this account of Popp and Riedler's project are all reckoned at atmospheric pressure

The Commission greatly approved of the turbines and compressors shown in this project, though they considered that the efficiency of the turbines, which are not run at the best speed, would be somewhat less than that assumed. This is not very important at Niagara. The Commission disapproved of the unlined vertical rock shafts for conveying water to the turbines. Of the different arrangements shown, they preferred the one with vertical axes to the turbines and compressors above-ground.

V. *Project of* G. F. Deacon, Esq., M. I. C. E., *and Messrs.* Siemens Brothers & Co., *of London.*

This is a project for the utilization of 125,000 horse-power by turbines, and its distribution electrically by continuous current, the dynamos being worked at constant current with varying speed and potential. Dynamos and turbines are underground in a rock gallery.

Hydraulic Arrangements. The water is conveyed in a surface canal, entering the canal from the river over a weir. Strainers and a traveling-crane to lift them for cleaning are provided. Directly from the bottom of the canal vertical shafts convey water to a group of turbines of 30,000 horse-power As the mouths of these shafts are below the water, they are intended to be closed, when necessary, by a cylindrical floating caisson gate, or valve. This is of steel, and can be lifted out of the water by a traveling-crane. The caisson is sunk by admitting water The rock shafts are twenty feet in diameter, lined, where necessary, with Portland cement concrete.

From each shaft the water is distributed to a group of twelve turbines. A horizontal tunnel leads each way from the bottom of the vertical shaft, and twelve iron supply pipes lead to the turbines

The turbines are inward-flow pressure turbines, of 2,500 horse-power each, with horizontal axis and suction pipes This is a form of turbine having great steadiness of speed. No regulating apparatus is used in the turbine, as it is considered that efficiency, except at full power, is of no importance at Niagara The speed is regulated by a sluice valve in the supply pipe, running on rollers, which diminishes the effective head, and, with this, the rate of discharge through the turbine. The turbine wheels are six feet in diameter, and a speed of 195 revolutions per minute. The turbines and dynamos are placed in two rock galleries, 780 feet in length, connected by cross galleries. Two vertical access shafts are provided. The main galleries are fourteen feet wide and twenty-six feet in height, being very much smaller than in some of the projects Each gallery has three electric traveling-cranes It is suggested that automatic self-closing valves may be used on the supply pipes, to provide against accident.

Electric Arrangements. To each turbine a dynamo is rigidly connected, without any coupling. The dynamos have ring armatures, and the electromagnet bobbins are wound in series with the armatures. Each dynamo gives a constant current of 400 amperes, with a potential depending on the speed. At 195 revolutions the potential would be 4,500 volts One switchboard is provided for each group of twelve dynamos, and to the switchboards ten mains are connected. There are appliances to connect any dynamo to any main; any two dynamos in series to any main; any two or more mains in series to any one or two dynamos in series. The fifty mains from the five switchboards are connected to a general switchboard above-ground, from which forty trunk mains start.

Distributing Mains. These would be placed underground. They consist of one-half square inch of copper insulated for 9,000 volts.

The mode of working is this One generator is started with voltage sufficient to send the full current of 400 amperes through the mains. Its speed is increased as the resistance increases till it has reached full speed. Then a second generator is started and run on closed circuit till the current is 400 amperes, it is then coupled to the trunk main and its speed increased with the load as before. The highest potential will only be used when the generators are working at maximum output. There is the same loss in the mains at all loads, but this is unimportant at Niagara. At full load the efficiency is greater than with the parallel system. There is no difficulty in constructing motors for 400 amperes. For electric lighting a low tension current at 120 or 130 volts would be obtained by dynamo motor transformers. These would feed a network of mains in the usual way.

Calculation shows, in Messrs. Siemens' opinion, that there is a gain of 10 per cent. of economy in the series system they propose over the parallel system with motor transformers, when working with full load.

The motors are series wound and worked with constant current. They are regulated by varying the field by partly short circuiting the electromagnet coils by means of a centrifugal governor.

Cost and Working Expenses. For Cataract City the cost, including working expenses, depreciation and interest on capital, is estimated at $12 75 per effective horse-power per annum distributed. For Buffalo the corresponding cost is estimated at $23.05 per horse-power per annum.

The Commission recognized the great originality and practical importance of the proposal of Messrs Siemens to work with constant current and varying potential. But they thought that the method of working on the system of parallel conductors with approximately constant potential was preferable for many reasons.

VI. *Project of Mr.* H D. PEARSALL, *of Orpington, England.*

This is a project for directly using the pressure of the head to compress air, and includes a general statement of a proposed mode of distribution. The water is admitted to a series of vertical cylinders, successively compressing the air in them till it escapes through a series of valves into the mains; the cylinders then discharge the water and refill with air A canal takes the water from the river and culverts, and iron pipes lead the water to the compressing engines. These are placed on three tiers, each tier using about one-third of the total head.

The peculiarity of Mr. Pearsall's arrangement is the mechanical control of the valves by small special air motors. Mr Pearsall claims, and no doubt rightly, that the water column and large, wet metal surfaces cool the air very effectively during compression. Mr. Pearsall allows a maximum velocity of 40 feet per second to the water in the main entering the compressing cylinder, the main being 5½ feet in diameter, and he assumes that the column is brought steadily and without shock to rest by the increasing air pressure. He calculates the time of one complete stroke at 4.7 seconds. From this he calculates that each compressing cylinder will compress 13,773 cubic feet of air per minute, and at the same time deliver 32 cubic feet of water under the same pressure, which can be used in special mains as a town water supply. Mr. Pearsall calculates

the mean effective pressure of the air during compression at 37 pounds per square inch, and the final at 150 pounds per square inch, in which case each engine will work to 2,224 horse-power, and on an equally theoretical basis he estimates the efficiency at 73.6 per cent.

The total plant consists of 63 compressing engines for 125,000 horse-power.

The whole of the engines are placed in an enormous pit or open excavation carried down nearly to the level of the tail-water.

Three mains are proposed connected by cross mains. The air mains to Cataract City are 2 feet 10 inches in diameter for a mile, diminishing afterwards The mains are laid in a trench covered with concrete slabs.

For the pressure water there are two mains 30 inches in diameter, diminishing gradually to 22 inches.

A Venturi meter, schemed on principles similar to those applied by Mr. Herschel, is proposed for measuring the air used by motors.

For transmission to Buffalo a loss of pressure of 25 per cent. is allowed. Three mains of 2 feet 10 inches in diameter are required. For pressure water, which it is also proposed to carry to Buffalo, two 30-inch mains are required. These mains are to be laid in filled-up trenches.

Two very small compressing engines of the type proposed have been constructed and worked. One of these was about 3 horse-power, the other about 5 to 6 horse-power. A third has recently been constructed of about 10 horse-power.

The Commission thought that it might be useful to experiment with a compressing engine of this type, but they noted that Mr. Pearsall's project is based throughout on conjectural estimates of the action of the water and on untried designs of valves and other auxiliary apparatus.

VII. *Project of Professor* ARNOLD LUPTON, *of Leeds, and* JOHN STURGEON, *Esq., of Chester.*

This is a complete project for utilizing the power of Niagara by turbines driving single-acting compressors of the type used in the Birmingham installation. As at Birmingham, a moderate air pressure is proposed Cataract City and Buffalo are not dealt with separately. The air main is designed to carry the whole 125,000 horse-power, under the idea that factories requiring power would come into existence along the line of main.

Messrs. Lupton and Sturgeon state at some length the special advantages of an air transmission scheme. Compressed air can be used in existing ordinary steam-engines, for driving steam-hammers, or small special domestic motors. It can be applied in ventilating, exhausting or refrigerating. It can be used for cupolas and furnaces, the pressure being adjusted by induction nozzles. Air motors may be used for driving dynamos for electric lighting and for working tram-cars It can also be used for warehouse hoists and hotel lifts. The use of compressed air would lead to an abatement of the smoke nuisance. There is nothing doubtful or experimental about a scheme of distributing power by compressed air.

Of 120,000 horse-power on the turbine shafts, Messrs. Lupton and Sturgeon estimate that 70,000, or 58.3 per cent., could be distributed and sold to consumers. If the air

is reheated before use the efficiency is greater. They ascertained that the cost of steam power at Buffalo ranges from $40 to $150 per horse-power per annum.

At Birmingham manufacturers are willing to pay for compressed air prices equivalent to $40 to $125 per horse-power per year of 2,700 hours.

In Paris the prices are higher. Looking at the price of coal in Buffalo compared with that in Birmingham, the manufacturers would probably be willing to pay $60 to $185 per horse-power per year of 2,700 hours.

Now apart from interest on capital, Messrs. Lupton and Sturgeon estimate that air power can be supplied in Buffalo at $7 per horse-power per annum.

Hydraulic Arrangements. A canal takes the water from the river, provided with ice fender and sluices which will cut off the water supply entirely if repairs are needed.

Eight branch canals on one side and nine on the other lead to the turbines of the air-compressors. At the furthest and narrowest end of the canal arrangements are made for an electric lighting station, driven by turbines. Each branch canal is provided with Stoney's frictionless sluices, similar to those used on the Manchester canal.

The turbine pits are arranged in blocks of 5,000 horse-power, one inlet from the main canal serving two blocks, or altogether 10,000 horse-power. Thirty-four turbines drive the air-compressors and one the electric-lighting plant. The vertical supply shafts to the turbines are 12 feet diameter.

The turbines are inward-flow pressure turbines. The action of the water on the turbines being radial, it is a balanced action. Each turbine is of 3,750 effective horse-power. The wheel is 8 feet diameter and makes 140 revolutions per minute. There are suction pipes to utilize the fall below the turbines. The water pressure is taken to the underside of the wheel, which is constructed to form a kind of hydraulic piston, and this pressure can support a load of 80 tons, more than enough to carry the weight of turbine and shaft. A cast-iron hollow shaft is proposed. The shaft is to run in bearings with lignum-vitæ steps. A cylindrical regulating sluice can be worked from above-ground

Gearing. To drive the horizontal crank shaft of the air-compressors at 80 revolutions from the vertical turbine shaft running at 140 revolutions, steel bevel wheels are proposed.

Air Compressors. Each turbine drives eight single-acting vertical compressors 43 inches diameter and 48 inches stroke. At full speed each cylinder will deliver 500 cubic feet of cold air at 5½ atmospheres (67½ pounds per square inch) pressure. The inlet valves are in the compressing piston and the delivery valves in the cylinder cover. Water is circulated through the piston and surrounds the compressing cylinder. Spray injection will be used, if found necessary. The compressors are placed in an excavation just below ground surface. This gives good foundation and permits the supply water to the turbines to circulate round the compressor cylinders. An engine-house is erected over the compressors, with a 10-ton traveling-crane. A small special electric plant for lighting the engine-houses is provided.

Altogether 34 sets of compressing cylinders, 8 cylinders in each, are provided, two sets being ordinarily held in reserve, or 256 cylinders in all. They are intended to deliver 128,000 cubic feet of cold air at 5½ atmospheres per minute.

Air Mains. The air is conveyed by branch pipes (with stop valves) to a large air main. Expansion joints are introduced at each junction. The air main increases in diameter till it reaches 10 feet in diameter. It is proposed to take the air main by Tonawanda to Buffalo. The diameter will be gradually reduced to 7 feet at Buffalo. From Hertel Avenue, in Buffalo, there will branch three principal lines of mains through Buffalo, east, center and west, all united by a main traversing the south of the city from east to west. Drawings are given showing the proposed construction of these mains The main is so designed that with 5½ atmospheres at Niagara, there will be 5 atmospheres of pressure at Buffalo, giving a working pressure of 60 pounds per square inch The question of using a higher pressure has been considered by Messrs. Lupton and Sturgeon. But on their method of working they doubt if there would be much economy in the cost of the main, and they attach importance to the storage capacity provided by the large main.

It is proposed to construct a tram road, worked by compressed air, over the line of main to Buffalo.

The main would be provided with Stoney roller sluices at every half mile

Meters of the type used at Birmingham would be employed to measure the air to consumers.

Electric Lighting Arrangements. Messrs. Lupton and Sturgeon do not see any large field for electric lighting at Niagara. They have, therefore, provided only for 30,000 16-candle power lamps The dynamos would be worked by four 1,100 horse-power turbines, one being in reserve. Each turbine works two dynamos of 500 horse-power. The dynamos are alternators at 2,500 volts Transformers will be used where necessary.

Beyond Cataract City, Messrs. Lupton and Sturgeon think it preferable to drive dynamos by compressed-air motors, and not to supply the electricity from a central station at Niagara. In Buffalo they think that 24,000 horse-power might be thus employed in electric lighting. They would distribute the electricity from four or five generating stations at 2,500 volts, transforming to a convenient potential at the consumers' premises. Or a low tension system might be used with a larger number of stations. One principal reason for preferring to generate electricity by compressed-air motors at Buffalo is this: Only in winter will much light be required before 6 P. M. By generating the electricity at Buffalo, the cost of canals, turbines, electric plant and conductors is saved. The facility of working numerous generating stations by compressed air is so great that Messrs. Lupton and Sturgeon incline to think that a safe and simple low tension system would be preferable to a high tension one, except, perhaps, at Cataract City.

The Commission thought the construction of the turbines, in this project, somewhat too complicated, and they objected to the use of the same vertical shaft for conveying water to the turbines and for the shaft of the turbine itself. They did not think the arguments for the use of single-acting compressors valid, and believed that is was in consequence of the inefficiency of the form of compressor adopted that Messrs. Lupton and Sturgeon had been driven to use so exceptionally large a main for transmission of the compressed air.

VIII. *Project of Messrs.* GANZ & Co., *of Budapest.*

This is a scheme for utilizing the power by partial-flow impulse turbines of 5,000 horse-power each. These have vertical axes directly coupled to dynamos of the same power, placed above-ground. The electrical part of the scheme is not fully worked out.

Turbines of less than 5,000 horse-power Messrs. Ganz do not consider practical, because the cost of the hydraulic arrangements becomes too great. They are satisfied that turbines as large as this can be constructed in a trustworthy manner. Rejecting the plan of placing the dynamos underground, no plan of transmitting the power to the ground surface appeared to them to be possible except that of a simple vertical shaft. The armature of the dynamo is fixed on this shaft, which augments the vertical load to be carried. But a special type of bearing which Messrs. Ganz have adopted completely meets this difficulty.

The head-race is provided with twelve sluices, but as these can only be opened or closed slowly a cylindrical sluice is only used immediately over each turbine supply shaft. The supply shaft is a vertical rock shaft lined with concrete. The turbines are a kind of partial-flow impulse turbine which, however, at full power, work as pressure turbines, without much loss of efficiency. Hence the fall below the turbines can be partly utilized. The vertical shaft is a solid steel shaft, running at 125 revolutions. The weight of turbine, shaft and armature is estimated at 125 tons. This is suspended from a very ingenious form of bearing, which has been used for similar cases with perfect success. It is really a kind of collar bearing, with an arrangement for pumping oil between the supporting surfaces, so as to convert it into a fluid bearing An hydraulic piston is also placed in the tail-race below the bottom of the shaft. A timber sluice, worked by hydraulic-pressure cylinder, is placed on the tail-race, so that access may be gained to the parts below the turbine. The regulating sluices of the guide passages of the turbine are worked by hydraulic cylinders. A centrifugal governor controls the action of these regulating sluices.

Electrical Arrangements. Alternate current (Zippernowsky) dynamos are proposed, working at 336 amperes at a potential of 10,000 volts Inside the armature frame rotates the field magnet. There are 2,500 complete periods per minute The exciting current is taken from a separate continuous-current exciter driven by bevel wheels from the turbine shaft The exciting current is 335 amperes at 200 volts.

The motors in the central station for driving the pressure pumps, cranes, etc., are continuous-current motors supplied from one of the exciting machines.

It is proposed to have twelve large alternating generators, ten for ordinary use and two in reserve. For coupling one machine in parallel to others already working starting resistances are used. For regulating the exciting current resistances are used which for large differences of potential are adjusted by hand, but for small differences by an automatic equalizer.

Primary Conductors. These pass by Tonawanda to a distributing station in Buffalo. They consist of two sets of twelve uncovered cables, one for outgoing and one for return. The total section is 1,848 square mm., which gives 25 per cent. loss in the electric main; the conductors are carried on iron supports 50 meters apart. Insulators on wood cross-bars are used. The standards also carry the wire of a telephone circuit.

Buffalo Distributing Station. Reaching Buffalo at 8,000 volts, the current is transformed to 12,800 amperes at 2,000 volts. A list of motors of 3 to 80 horse-power is given, having a commercial efficiency of 75 per cent. in the smaller to 90 per cent. in the larger sizes. The speed of the motor depends on the frequency of the alternations and is independent of the load. The smaller sizes require a lower potential and have special transformers. The larger sizes can take the current at 2,000 volts. The turbines shown in the drawings of this project are of a very satisfactory type, and the general arrangement of the hydraulic machinery is excellent. The extensive and successful experience of Messrs. Ganz & Co. with alternate current dynamos of high potential gives importance to their proposals for the distribution of the power, but details of the electrical part of their project are not fully described.

IX. *Project of Messrs.* Escher, Wyss & Co., *of Zurich, Switzerland.*

This is the hydraulic part only of a project for utilizing the power by turbines and distributing it electrically.

The electrical part was to have been added by the Maschinenfabrik Oerlikon. Owing to unavoidable circumstances the electrical part could not be supplied in time, and only a sketch of the electrical arrangements which would have been proposed is given. It may be taken, however, that the hydraulic arrangements of Messrs. Escher, Wyss & Co. have been so arranged in consultation that they would have been perfectly suitable for driving such electrical machinery as the Oerlikon Company considered suitable for the Niagara project. Some details of compressed-air plant to be used as an adjunct are also given.

Messrs Escher, Wyss & Co. aim at selecting turbines of the highest efficiency, on the ground that so the cost of the machinery is diminished. This and the local condition requiring the turbines to be placed in pits lead to the choice of pressure turbines, which occupy small space, run at high speed, and can be constructed of large power.

As to modes of distributing power, wire ropes and pressure water are dismissed as unsuitable—the latter chiefly on the ground of costliness Compressed air, they think, offers greater advantages. For certain industries only compressed air would be suitable, and hence transmission in this way is studied for comparison with the electrical system Electricity in their opinion is the most convenient means of distribution, best admitting of gradual extension.

The following projects are given:

Project A. A plant of 100 groups of air compressors above-ground, driven in pairs by turbines of 2,500 horse-power, with vertical axes and gearing. Speed of turbines, 250 revolutions per minute, of air-compressors, 60 revolutions.

Project B. A plant of 25 turbines of 5,000 horse-power each, with vertical shafts coupled directly to dynamos placed above-ground. Speed, 300 revolutions per minute.

Project C. A plant of 12 turbines, each of 10,000 horse-power, with horizontal shaft, each driving two dynamos placed underground. Speed, 240 revolutions per minute.

To reduce excavation the turbines are placed directly over the tail-race tunnel, in galleries transverse to the tunnel, leaving the rock solid between the series of supply

shafts. Access is gained to this series of short transverse galleries by a gallery parallel to the tunnel, but on one side of it.

In Projects A and B, vertical rock shafts or pits contain both the supply pipes and the turbine shafts. In Project C, the vertical rock shafts contain the supply pipes of the turbines only.

Turbines. All the turbines are axial-flow pressure turbines, with suction pipes. The water is conveyed to the turbines in iron supply pipes passing down vertical rock shafts. Sluices are arranged to cut off the water completely when necessary.

The balancing of the weight and pressure on the turbines is effected in different ways.

In the Air-Compressing Project A, a piston on which the water pressure acts supports the turbine, gearing and vertical shaft. The space above the piston is in communication with the suction pipe. A throttle-valve on this connection permits the regulation of the supporting force of the piston. In Project B, double turbines are used, one discharging upwards, the other downwards. The upper turbine is larger than the lower one, so that the water pressure has an excess of upward pressure to balance the weight of the shaft and turbine. In Project C, the turbines have horizontal shafts, two equal turbines are fixed on the shaft, the pressure on one just balancing that on the other.

It is not practicable to regulate turbines of the type here chosen by sluices in the guide passages. The plan adopted is this. A governor acts on the distributing valve of a small hydraulic motor. This actuates a cylindrical sluice on the suction pipes, or, in the case of some auxiliary turbines, a throttle-valve in the supply pipe. The diminution of efficiency in this mode of regulation is of no importance at Niagara, where it is important to obtain the greatest useful effect only when working at full power

As to the general disposition of the central station, it needs only here to mention that a central vertical shaft is provided for access. Here would be placed lifts, water-pumps, ventilators, etc, driven by secondary or motor dynamos. To work these a special group of four 400 horse-power turbines and dynamos generators has been designed.

X. *Project of Messrs.* J. J. Rieter & Co., *of Winterthur, Switzerland.*

This consists of designs of three arrangements of pressure turbines.

It contains, also, details of a telodynamic or wire-rope transmission.

Project A. Group of four turbines, with vertical axes of 2,000 horse-power each, or a total of 8,000 horse-power. The turbines are pressure turbines, with suction pipes running at 180 revolutions per minute. The vertical load is supported partly by a pivot, partly by a piston or hydraulic support, placed above the turbine.

At the top of the shaft is a collar-bearing and bevil-gearing driving wire rope pulleys. Each turbine is regulated by a relay governor acting on a throttle-valve.

From the head-race, provided with sluices and strainers, a vertical unlined rock shaft conveys water to the group of four turbines. Two other shafts serve for access, and contain the transmission shafts of the turbines

Project B. Group of four pressure turbines, each of 2,500 horse-power, with horizontal axes and suction pipes. Speed, 250 revolutions per minute. The turbines are placed opposite in pairs, and collar-bearings take the axial thrust. A relay governor and throttle-valves are used for regulation.

PROJECT C. Group of two pressure turbines, of 5,000 horse-power each, running at 190 revolutions per minute Horizontal axes. The other arrangements as above.

Cable Transmission. Messrs Rieter & Co. have constructed most of the wire-rope transmissions which have been erected. Each cable transmits 333 horse-power, and the ordinary distance of the piers and pulleys is 330 feet. The loss in transmission is stated to be only 7 horse-power for each cable for each span.

The cost of the turbines of group in Project A, with pipes, sluices, shafting, governors, etc., amounts to $14.16 per horse-power. The corresponding cost of the turbines, etc., in Project B amounts to $4 57 per horse-power. The cost of the turbines, etc., in Project C amounts to $4.42 per horse-power.

Including the buildings and excavations, Messrs. Rieter estimate the cost of the turbines, etc., in Project A at $28 16, those of Project B at $9.06, and those in Project C at $8.09 per horse-power.

The machinery for a central station, for cable transmission, arranged for 8,000 horse-power, is estimated at $3 25 per horse-power. The transmitting cables and intermediate stations would cost $5.25 per horse-power for each distance of 110 yards The machinery for a terminal or receiving station, arranged for 1,000 horse-power, would cost $4 11 per horse-power.

XI *Project of* M. LEON VIGREUX, *of Paris, and* M. LEON FERAY, *of the firm of* FERAY & Co., *of Essones.*

This is a project for the utilization of part of the power at Niagara by turbines, and its distribution to Cataract City by high-pressure water. The project proposes to deal with 50,000 horse-power, leaving the rest of the power to be distributed electrically

The following general arrangement is suggested Six working groups and one reserve group, of 10,000 horse-power each, driving the electric generators. Two groups for exciting current, lighting the station and auxiliary purposes, one working and one in reserve, each of 10,000 horse-power. Five working groups and one reserve group, driving pressure pumps of the hydraulic system. All the machinery is placed underground in rock galleries.

Turbines. The governing consideration is taken to be that the pumps must be driven without intermediate gearing. Hence, impulse partial-admission turbines of great diameter are chosen, having horizontal shafts, which are extended to form the crank shafts of the pumps.

The authors examined the plan of driving the pressure pumps directly by pressure engines, acting with the water pressure due to the head, but found they would have to be of impracticably large dimensions.

A large vertical rock shaft conveys water to a group of 10,000 horse-power. This terminates in an iron pipe which bifurcates below the floor of the pump chamber. There are two pairs of turbines, each pair consisting of two closely coupled wheels having the same shaft. The wheels are nearly 34 feet in external diameter. Each single wheel is 2,500 horse-power; each pair of turbines drives six double-acting pressure pumps, with an accumulator for each set of three pumps. The turbines and pumps run at 30 revolutions per minute. The efficiency of the turbines is assumed at 70 per cent., but is expected to be greater. An automatic arrangement connected with the accumulator acts

on the turbine stop valve and regulates the stopping and starting of the pumps, according to the demand for power.

Pressure Pumps. The working pressure at the pumps is 783 pounds per square inch. This will give about 710 pounds per square inch in the distributing mains. The authors reject Armstrong pumps, which have internal packings, in favor of Girard pumps, all the packings of which are in external stuffing-boxes. The efficiency of the pumps is assumed at 85 per cent. Diameter of plungers 17½ inches, stroke 2 feet 6 inches. For a group of 10,000 horse-power there are twelve pumps, discharging through two pipes 24 inches diameter Hydraulic accumulators placed underground regulate the pressure and rate of discharge.

The accumulators are differential accumulators; the pressure of the fall acting on a large piston balances the pressure of the pumps on a small piston. The accumulator pistons are 1′ 1½″ and 4′ 3″ diameter, and have a stroke of 18 inches There is one accumulator to each set of three pumps. A relief valve is placed on each discharge pipe, loaded by the pressure of the head

Underground Pumping Station. This is a gallery 604 feet long, 112 feet wide, divided by piers into three longitudinal bays. A ventilating shaft and suction fan, driven electrically, are provided. Traveling cranes, worked electrically, are provided in the galleries.

Distribution of the Pressure Water. A pair of distributing mains 24 inches in diameter, from each set of 12 pumps, would together form a closed circuit to diminish interruption from an accident to the main. At important distributing centers accumulators would be established. Three types of partial-admission impulse turbines are described, which would be suitable as motors driven by the pressure water.

The complete cost of machinery, excavation and buildings appears to be estimated at a little under £6 per horse-power at the turbine shafts, or about £7 10s per horse-power distributed in Cataract City. This does not include any allowance for the cost of a proportion of the tail-race tunnel nor for motors to use the pressure water.

When a large amount of power has to be distributed by water, even at the enormous pressure here proposed, the whole apparatus becomes extremely cumbrous For the transmission of 50,000 horse-power, for instance, it appears that ten steel mains or delivery pipes would be required, each of two feet internal diameter. The arrangement adopted necessarily involves the placing of the pressure pumps underground, and they require a chamber of very large size.

XII. *Project of the* PELTON WATER WHEEL COMPANY, *of San Francisco, California*

These competitors assume that the head at Niagara is far too great for pressure turbines, and hence Pelton wheels of the type made by the Company are proposed.

The water is taken to the wheels in vertical shafts, each supplying a group. Lateral tunnels convey the water to each wheel, and tail-races are cut from the wheels with a section of 48 square feet and a slope of 1 in 10 to the main discharge tunnel.

The group shown consists of one 4,000 horse-power Pelton wheel driving service pumps, one 4,000 horse-power Pelton wheel driving high-pressure pumps, one 4,000 horse-power Pelton wheel driving air compressors, and four 2,000 horse-power Pelton wheels driving dynamos; altogether, a group of 20,000 horse-power.

Two vertical shafts in the rock serve for access and ventilation, and up these are carried vertical rods working the service pumps above-ground. All the rest of the machinery is in an underground gallery.

The electric section consists of four Pelton wheels, 14 feet 6 inches in diameter, arranged in pairs and running at 60 revolutions per minute. Each wheel is supplied by five nozzles The stop valves on these nozzles are worked hydraulically. It is stated that the wheels will run with a variation of speed not exceeding 3 per cent.

For the air-compressing arrangement, a Pelton wheel, 21 feet 6 inches diameter, is shown, running at 40 revolutions per minute. This is supplied by eight nozzles. The nozzles have stop valves worked by hydraulic pressure and controlled by hand or automatically by the air pressure.

For the service pumps, two Pelton wheels are shown, each 21 feet 6 inches in diameter, running at 40 revolutions per minute. They have eight nozzles with stop valves A crank on the shaft works vertical rods to an angle bob on the ground level, and from this pumps are worked horizontally.

A relay governor is shown for actuating the stop valves of a set of nozzles successively in cases where regular speed is necessary.

No machinery of distribution is shown, and the project does not go further than to indicate the applicability of Pelton wheels of great power to drive machinery of various kinds

The Company propose to guarantee an efficiency for their wheels of 80 per cent, and state that they expect to realize 85 per cent.

The cost of the water-wheels, exclusive of excavation and erection and exclusive of pumps, compressors and dynamos, is given as $3 90 per horse-power

XIII *Project of Professor* G Forbes, *of London.*

This is a project for the distribution of power electrically, the dynamos being placed in underground galleries, where they would be worked directly by turbines. The hydraulic part of the arrangement is not dealt with. The project is accompanied by an extremely full and careful memoir, in which the conditions of economical distribution by electricity are discussed There is also a very detailed estimate of the cost of distribution by the plans proposed.

Professor Forbes has come to the conclusion that the only practicable scheme for the transmission of power to Buffalo, and the best scheme for Cataract City, is to adopt alternating current generators and motors. He proposes to transmit to Buffalo at 10,000 volts and to Cataract City at 2,000 volts, but the same machines, without any alterations, are used in both cases and are perfectly interchangeable. For Buffalo the current is generated at 2,000 volts and the voltage is raised to 10,000 by converters. The current is carried by bare copper conductors on poles to five distributing stations in Buffalo, and the voltage reduced by converters to 2,000 volts. This current may be carried direct into the town for electric lighting or for supplying large motors. Some of these motors may be used to generate continuous currents at low tension for distribution over short distances for light or power purposes.

Cheap power could be supplied, according to Professor Forbes' estimate, at the five stations in Buffalo at a cost, so far as the electrical part of the work is concerned (that is exclusive of the cost of turbines at Niagara), of $23.30 per horse-power per

annum. The power delivered would be 68 per cent. of the power given off at the turbine shafts at Niagara. Low tension continuous currents at a tension of 500 volts could be conveniently generated for working tramways. At Cataract City the efficiency of the electrical system would be 81 per cent., and the cost, excluding hydraulic works, $16.60 per horse-power per annum.

Professor Forbes insists on an essential difference in the conditions of supply to Cataract City and Buffalo. The distance from the Falls to Buffalo in a direct line is twenty miles, and the route to be followed by a cable may be thirty miles. On the other hand, the distance from the Falls to the factories of Cataract City does not exceed two or three miles. The latter may be supplied with power electrically with such differences of potential as have already been used in electric lighting. In the case of Buffalo, if only such pressure were used, the cost of the conductor, and consequently of the power, at Buffalo would be too great. At Cataract City 2,000 volts or less give an economic distribution. For Buffalo 10,000 volts must be used to obtain a similar result. Then again, Buffalo is a town already built, and the electric system must be adapted to it. Cataract City is still to be built, and can be planned to suit the requirements of the electric distribution.

For Buffalo, Professor Forbes proposes a distribution of power of three different characters: (1) Cheap power supplied at the outskirts of the town, by a current transmitted from Niagara at 10,000 volts; (2) power distributed through the town for large motors at 2,000 volts, the cost of which will be somewhat greater, (3) electricity distributed at low pressure throughout the town for small workshops, and for independent motors to separate machines. Probably $50 per horse-power per annum might be charged for the first kind of supply, somewhat more for the second, and at least $100 for the third, and these prices would yield an ample profit.

Current Density in Conductors. The primary problem of design is to determine the size of the conductor. According to a law first stated by Sir William Thomson, the most economical distribution will be achieved if the annual interest on the value of the copper conductor is equal to the annual value of the energy used up by the resistance of the conductor. If the conditions are in any way arbitrarily restricted, this equality does not necessarily hold good. But the principle of Sir William Thomson's law is that which must be used in determining the best size of conductor. In the present case the most convenient statement of the condition of greatest economy is this. The density of current should be such that the cost per horse-power per annum of power delivered in Buffalo is less than with either a slightly greater or a slightly less density of current To apply this law an estimate must be formed of the cost of producing power at Niagara. The cost of the tail-race tunnel is given, and it amounts to $4,000,000. Professor Forbes does not enter into the hydraulic part of the project, and the cost of the hydraulic machines can, therefore, only be very roughly estimated. Still, as the estimate is only wanted to determine the character of the electrical appliances and the size of conductor, it is probable that if an error of estimate is committed it will not seriously alter the conclusions arrived at. The rough estimate taken as a basis of the following calculations is that the cost of the tunnel, head-race, sluices, shafts, water motors, dynamos and buildings, at the generating station at Niagara, will be $12,000,000 for 120,000 horse-power. Allowing for depreciation, interest and working expenses, the annual cost per

horse-power, delivered at the terminals of the generating dynamos in Niagara, would be $12.50.

Professor Forbes then assumes different densities of current in the conductor and different differences of potential at Niagara. Calculation gives the loss of energy in the conductor to Buffalo, and consequently the amount of energy delivered. The cost of the motors for this power and of the conductor can be ascertained. Consequently the cost per horse-power of the energy delivered in Buffalo can be estimated for the assumed density and voltage.

For a potential of 2,000 volts in the most favorable case the cost at Buffalo of a horse-power is found to be about $60 per annum.

This Professor Forbes holds to be inadmissible, for he thinks it may be assumed that if the power is not obtained at a net cost of about $25 per horse-power per annum the scheme would not be a financial success. By increasing the pressure to 10,000 volts the cost per horse-power per annum, in the most favorable case, comes to about $26, which is practicable. At Cataract City 2,000 volts is sufficient to give an economical distribution, the cost being estimated at $23.60 per horse-power per annum.

The general result of the calculations is the adoption for Buffalo of a current density of 500 amperes per square inch, and an electric pressure of 10,000 volts For Cataract City a current density of 500 amperes per square inch, and an electric pressure of 2,000 volts. If a lower pressure is considered desirable, then 1,000 volts for Cataract City will give nearly as great an economy.

Types of Dynamos and Motors. Continuous and alternating current machines both work well as motors, and the efficiency of the best of each type is about the same.

All continuous-current motors in practical use are continuous-current generators pure and simple. They are convenient for use in the workshop. As soon as the current is applied the motor works, even though the full load be on, and if the motor is overloaded the rotation is still maintained

Alternate current motors may be divided into synchronizing and non-synchronizing motors The former are alternate current generators pure and simple. The latter form a special class, depending for their action on principles discovered by Tesla and Ferraris.

Synchronizing motors require to be started by some independent motor. Mr Mordey uses a small independent continuous-current dynamo, which ordinarily is driven by the alternate-current motor, and at the same time excites its field magnates. Part of this current is used to charge a set of accumulator cells. When the alternator is to be started, a current from the accumulator drives the exciting dynamo as a motor, and this puts the alternator into motion. Such an arrangement is quite suitable for a sub-station, but is not so suitable for a factory where machinery may have to be started and stopped frequently. The synchronizing motor has the further defect that if it be overloaded it gets out of synchronism and stops. Mr. Mordey's alternator, however, will stand considerable overloading without getting out of step and stopping. On the other hand, alternating motors have the advantage that whatever the load may be the speed remains constant.

The only non-synchronizing motor which has been constructed in a practical form is the Tesla motor, which Professor Forbes has experimented on at Pittsburgh at the works of the Westinghouse Electric and Manufacturing Company. Motors of this class have not been made of any large size.

For Cataract City, where electricity can be distributed economically at 2,000 volts, either continuous-current or alternating-current motors could be used. The alternator has the advantages of constant speed and the absence of a commutator. On the other hand, it cannot be started and stopped with facility. The Tesla motor has the advantage that it has no brushes or rubbing contact, but cannot at present be recommended except for small powers. For convenience Professor Forbes gives the preference to the synchronizing alternator. As to economy, a question as to the size of machine arises. The largest sizes of either continuous or alternating-current machines hitherto extensively used are those of about 500 or 600 horse-power The design of continuous-current machines is so simple that there is no reasonable doubt that larger machines could be constructed, and for machines of 2,500 horse-power the cost would probably not exceed $10 per horse-power. No quite satisfactory design of an alternator of large power has yet, in Professor Forbes' opinion, been produced, and hence he recommends machines of about 500 horse-power, costing $19 per horse-power. In deciding between large continuous-current and smaller alternating-current machines, it appears that the only satisfactory solution of the problem of transmission to Buffalo is by alternating currents. No continuous-current machine can be made to work efficiently and continuously at 10,000 volts. Nor do continuous currents permit the use of converters. It is very desirable, in Professor Forbes' opinion, that the same type of machine should be used both for Cataract City and Buffalo. Hence, in spite of extra cost, he gives the preference to the use of alternating generators and synchronizing motors both for Cataract City and Buffalo.

Professor Forbes thinks that alternating machines could be constructed to give directly 10,000 volts. On the whole, however, he recommends producing the current at 2,000 volts and transforming to 10,000 volts. At Buffalo the current would again be reduced by transformers to 2,000 volts.

Conductors for Transmission Telegraph poles and well insulated cables are proposed for Cataract City. The case of transmission to Buffalo is very different. (1) To diminish lag of the current, dynamo machines of small self-induction must be used (2) An alternating current is confined more or less to the exterior of the conductor The thickness of the conductors must therefore be small. (3) Static induction diminishes the potential at the far end, hence the cables should have small capacity. (4) To avoid absorption of electricity in the dielectric, it is preferable to insulate the conductors by air. (5) To prevent inductive reaction between conductors carrying currents in different phases the generators should all work in parallel on the same conductors. (6) Disturbance of telegraphic and telephonic wires may be diminished by perfect insulation and placing the positive and negative wires close together.

Bare copper conductors are proposed in the form of stranded cable. These are supported on porcelain insulators with oil cups (three in number for each insulator), the conductors are carried on poles, separate poles being used for positive and negative wires. Four sets of poles are proposed, so that when the load is light two may be put out of use for repairs.

Distribution of the Current. In Cataract City all the motors would be put in parallel on the mains. In Buffalo the electric pressure would be transformed down to 2,000 volts. Part of the current would be utilized by synchronizing motors for developing power. Part would be transmitted by underground insulated cables to factories, or

to subsidiary stations from which it was desired to distribute a continuous low tension current. A synchronizing motor would in that case be used to drive a continuous-current dynamo

ESTIMATE OF COST, EXCLUSIVE OF HYDRAULIC MACHINERY AND ITS ADJUNCTS.

Estimates are given of the cost of the electric-generating machinery, transformers, conductors and motors, and of the excavation and buildings required for placing them Taking 5 per cent. interest on capital, 10 per cent depreciation for machinery, and 2½ per cent on all other works, the following estimates of cost are arrived at, for delivering a horse-power in the form of mechanical energy. (The cost of motors, and the loss in them, is included) The horse-power delivered is taken to be 81 per cent. of 70,000 horse-power at Cataract City, and 68 per cent of 50,000 horse-power at Buffalo.

	No I Buffalo, Alt Currents	*No II Cataract City, Alt Currents.*	*No III. Cataract City, Con Currents*
Interest . . .	$298,114	$330,379	$330,597
Maintenance and Depreciation	420,062	507,321	515,677
Working Expenses .	75,000	102,200	102,200
Total Annual Charge	$793,176	$939,900	$948,474
No of Horse-power Delivered . .	34,000	56,700	56,700
Cost, per Horse-power, per annum .	$23 30	$16 60	$16 70

The Commission were not convinced that the reasons given by Professor Forbes for an alternating-current system, in preference to a continuous-current system, were sufficient to establish his case.

XIV. *Project of the* NORWALK IRON WORKS COMPANY, *of South Norwalk, Connecticut, U. S. A.*

This is a project for a group of air-compressors of 10,000 horse-power, driven by Pelton water-wheels The compressors are vertical cylinder compound compressors, and are placed in underground chambers, indeed, with the form of water-wheel adopted an overground position is almost impossible.

Compressors. The cylinders of the compressors are 66 inches and 39 inches diameter, the stroke is 66 inches and the speed 55 revolutions per minute Four such machines require to be driven by water-wheels of 10,000 horse-power when furnishing air at 147 pounds per square inch (above atmosphere). The horizontal shafts of the Pelton wheels form the crank shafts of the air-compressors.

The chief peculiarity of the compressors is the use of Corliss intake and delivery valves. There is a water circulation in jackets round the cylinders and cylinder covers The air is to be subjected to a water spray before being compressed, so as to saturate it with moisture. But spray is not used in the cylinders An intercooler is used between the low pressure and high pressure cylinders of the compressor.

A ten-foot service shaft leads to each compressor chamber.

The Air Main. A series of calculations are given of the cost of a horse-power in Buffalo, with different sizes of main and different initial and terminal air pressures. As a result a main of 40 inches diameter is chosen, working with 147 pounds (above atmosphere) at the compressors and about 80 pounds per square inch in Buffalo. The general

arrangement for a station having five groups of compressors working altogether at 50,000 horse-power, reckoned on the water-wheel shafts, is this: The delivery pipes from the compressors are connected at the surface to two parallel 40-inch mains of about 1½ miles in length. These two mains then join into a single 40-inch main for conveying the air to Buffalo. It is assumed that all moisture will be deposited in the first 1½ miles of main. If in winter obstruction arises from ice, one of the parallel mains can be discontinued for clearing. The mains are laid on the surface of the ground, with expansion joints every 500 feet.

The Water-Wheels. The Pelton water-wheels are 15 feet 8 inches diameter, and each develops 5,000 horse-power at 55 revolutions. The stop valves of the nozzles are controlled by a differential valve actuated by compressed air, and also by a speed governor. A one-inch pipe led back from Buffalo supplies the air pressure controlling the stop valves. The Norwalk Company think that variations in demand in Buffalo would thus be rapidly met before the general pressure in the air main has altered

The cost of installation for one horse-power delivered to a consumer in Buffalo is estimated at $171 47. This includes excavation, turbines, compressors, delivery pipes, and a pro rata part of cost of tail-race tunnel.

An alternative plan is suggested in which air is compressed to 34 pounds per square inch for distribution to Cataract City. Part of this air is further compressed to supply Buffalo at a delivery pressure of 80 pounds.

PART III.

The preceding part of this Report contains abstracts of the documents accompanying those projects which were judged to comply with the terms of the letter of invitation to compete issued by the Cataract Company. An endeavor has been made to render these abstracts as complete and intelligible as was possible without the aid of drawings. It should be recollected that in this part of the Report the opinions and statements are those of the competitors, and it must not be assumed that in all cases the Commissioners agreed to them. Where, on special points, the Commission expressed an opinion, that has been explicitly stated.

The result of the examination of these projects by the Commission was the award of the following prizes and premiums.

AWARDS OF PRIZES.

COMBINED PROJECTS FOR HYDRAULIC DEVELOPMENT AND DISTRIBUTION OF POWER.

1st Prize of £600. Not awarded.

2nd Prize of £500.

Messrs. Faesch & Piccard, Geneva, and Messrs. Cuénod, Sautter & Co., Geneva.

3rd Prize of £200.

M. Hillairet and M. Bouvier, Paris.

M Victor Popp, Paris, and Professor Riedler, Berlin.

Professor L. Vigreux and M. Leon Levy, Paris

The Pelton Water Wheel Co., San Francisco, Cal , and the Norwalk Iron Works Co., South Norwalk, Conn.

PROJECTS FOR HYDRAULIC DEVELOPMENT.

1st Prize of £200.

Messrs. Escher, Wyss & Co , Zurich.

2nd Prizes of £150.

Messrs Ganz & Co., Budapest.

Professor A Lupton, Leeds, and Mr. J Sturgeon.

PROJECTS FOR DISTRIBUTION.

No prize awarded.

No first prize was awarded for a Combined Project for Hydraulic Development and Distribution of the Power. There was no project which, in the opinion of the Commission, could be recommended for adoption without considerable modification. On the other hand, with the consent of the Cataract Company, some third prizes were given which were not offered in the letter of invitation.

The following are the premiums awarded to all the competitors who, in the opinion of the Commission, complied with the terms of the letter of invitation.

PREMIUMS AWARDED.

A. For Combined Projects. Premiums of £200.

1. Messrs. Cuénod, Sautter & Co. and Messrs. Faesch & Piccard.
2. Professor Vigreux and M. Levy.
3. M. Hillairet and M. Bouvier.
4. Professor Riedler and M. Popp.
5. Mr. G. F. Deacon and Messrs. Siemens Brothers.
6. Mr. H. D. Pearsall.
7. Professor Lupton and Mr. Sturgeon.
8. Messrs. Ganz & Co.

B. For Hydraulic Projects for Developing the Power. Premiums of £100.

1. Messrs. Escher, Wyss & Co.
2. Messrs. J. J. Rieter & Co.
3. Professor Vigreux and M. Feray.
4. The Pelton Water Wheel Company.

C. For Projects for Distributing Power. Premiums of £100.

1. Professor G. Forbes
2. The Norwalk Iron Works Company.

Reviewing the whole of the projects, there were two or three points of primary importance as to which the Commission came to a definite expression of opinion.

In the first place, they were opposed to the plan of placing heavy and important machinery, requiring constant care and supervision, in underground galleries There appeared to be no real difficulty or serious additional expense in the adoption of turbines with vertical shafts supported by fluid pressure. They therefore preferred those arrangements in which the dynamos or air compressors were placed above-ground.

In the next place, the general opinion of the Commission was in favor of the adoption of electrical methods as the chief means of distributing the power, though perhaps not as the only means. In the selection of electrical methods they were not convinced of the advisability of departing from the older and better understood methods of continuous currents in favor of the adoption of methods of alternating currents.

On a third point the Commission came to a conclusion which differed from the view taken by any of the competitors.* They considered that it would be necessary to have a tunnel or subway in which to place the main electrical distributing conductors. In such a subway the conductors could be of bare copper placed on insulators; if the conductors were so placed in a subway, the greatest facility would be afforded for erection, for repairs, for inspection and for cleansing; and there would be the greatest

* M. Hillairet came nearest to proposing such a system of accessible subways as the Commission recommend

security from accident due to lightning, to rain or snow, or to private or public wanton mischief. These considerations appeared to the Commissioners to be so important that they would justify the excess of cost involved in the construction of the subways, which, however, would probably not be great.

W. C. UNWIN,

Secretary to the Commission.

LONDON, April 13, 1891.

APPENDIX F

WHEN NIAGARA RAN DRY

THE NIAGARA RAN DRY

IT HAPPENED FORTY-FIVE YEARS AGO YESTERDAY

MEN WALKED AND DROVE FAR OUT INTO THE CHANNEL—THE STATEMENTS OF MESSRS. STREET, MACKLEM, AND BOND—A GREAT RIVER WHICH DISAPPEARED FOR A DAY

NIAGARA FALLS, March 31, 1893 —It is just forty-five years ago today that the great Niagara River went dry. It was the only time in history that this extraordinary freak of nature was ever known to take place.

Many have questioned the occurrence and some have denied that such a thing could be, but on the morning of March 31, 1848, the waters receded and the bed of the river above the Falls was exposed to view. The best witness of this event is Bishop Fuller of Hamilton, Ontario. In an interview with THE NEW YORK TIMES's correspondent he said:

"I did not see the occurrence myself, but I was told of it the next day by my brother-in-law, Thomas C Street, M. P., who had a grist mill on the rapids above the Falls He said that his miller knocked at his bedroom door about 5 o'clock in the morning and told him to get up quickly, as there was no water in the mill race and no water in the great river outside the mill race. He said that he was startled at the intelligence and hurried out as soon as he could dress himself. There before him he saw the river channel, on whose banks he had been born thirty-four years previous, almost entirely dry

"After a hurried breakfast Mr Street and his youngest daughter went down about three-quarters of a mile to the precipice itself, over which there was so little water running that, having provided himself with a strong pole, they started from Table Rock and walked near the edge of the precipice about one-third of the way toward Goat Island, on the American shore Sticking her father's pole in a crevice of the rock, Miss Street tied her pocket handkerchief firmly on top of the pole Mr Street said that he turned his view toward the river below the Falls and saw the water so shallow that immense jagged rocks stood up in such a frightful and picturesque manner that he shuddered when he thought of his having frequently passed over them in the little Maid of the Mist.

"He then returned home and drove from the Canada shore about a half mile above the Falls, opposite Goat Island, and then drove out into the river bed When he told me this he reproached himself very much for not having sent for me. I was about eight miles distant, but he said that, although he had several times thought of doing so, he each time concluded not to do it lest before we could reach the wonderful scene the waters would again come rushing down the river bed. Of course every one was speaking of the wonderful event when I was out there the next day, and I have heard others who witnessed it speak of it since that time.

"Mr. Street's theory to account for the recession of waters was this: That the winds had been blowing down Lake Erie, which is only about eighty feet deep, and had been rushing a great deal of the water from it over the Falls. Then suddenly changing, the wind blew this little water (comparatively speaking) up to the western portion of the lake. At this juncture the ice on Lake Erie, which had been broken up by these high winds, got jammed in the river between Buffalo and the Canada side, and formed a dam which kept back the waters of Lake Erie a whole day.

"I wrote to L. F. Allen of Buffalo, a well-known gentleman of that city, in 1880, giving Mr. Street's statement and asking him if he recollected anything about the occurrence. His reply was as follow.

" 'Your favor of the 9th inst. received. The fact relating to the low water mentioned by Mr. Street as having occurred at Niagara Falls I well recollect, although I have no precise data as to the month or year in which it occurred. It was so remarkable as to be noticed in Buffalo newspapers. Nor do I recollect whether the subsidence of the river waters was caused by a dam of ice at the outlet of Lake Erie or by a strong east wind which sometimes, by blowing the water up the lake, makes very low water in the river for many hours.

" 'I knew Mr. Street personally very well and should have entire credence in any statement he should make of his own knowledge. That Mr Street could have driven his horse for several hundred feet into the bare bed of the river on the Canada side I have no doubt. I have lived in Buffalo fifty-three years and have witnessed so many fluctuations in the levels of the lake and river that I have perfect confidence in the late Mr. Street's account of the fact you named. He was a gentleman of such accurate statements that no one knowing him could doubt any one he should seriously make

" 'I am also enabled to give you copies of two declarations which were furnished me, one from an aged gentleman—Harry Bond of Chippawa—and the other from a leading gentleman in the place, a Justice of Peace and a notary public and a person doing an extensive business as a tanner.'

"Mr. Bond's declaration is as follows:

" 'County of Welland—To wit I, Henry Bond, of the village of Chippawa, in the County of Welland, do solemnly declare that I remember the occurrence of there having been a day during which so little water was running in the Niagara River that but a small stream was flowing over the Falls of Niagara on that day.

" 'It happened on or about the 31st of March, 1848, A. D , and I remember riding on horseback from below the flouring mills and cloth factory of the late Thomas C Street, Esq , out into the bed of the river and so on down outside Cedar Island to Table Rock, further up the Niagara River at the village of Chippawa, where the Welland River empties into the Niagara that there was so little water running that the Welland River was nearly dry, only a little stream running in the centre I recollect a number of old gun barrels having been found in the bed of the Welland River at the junction with the Niagara River, supposed to have been thrown into the river during the war of 1812.'

"The second declaration is as follows

" 'County of Welland—To wit: I, James Francis Macklem, of the village of Chippawa and County of Welland, Province of Ontario, notary public and Justice of the Peace, do solemnly declare that about the 31st day of March, A. D. 1848, the waters of the Niagara River were so low that comparatively but little water flowed over the Falls for a whole day. I well remember a flag which was fixed upon a short staff and planted far out from Table Rock, and very near the brink of the precipice, which appeared to be over one-third of the way across the river between Table Rock and Goat Island.

" 'This flag was placed there by the late Thomas C. Street, he having walked out to that spot from the Table Rock upon the bed of the river, where the waters had previously

rushed down in great force. The phenomenon of the Falls of Niagara running dry, as was the term used in speaking of the occurrence, caused great excitement in the neighborhood at the time.'

"Thus it will be seen that the occurrence is clearly proved There are many stories afloat in regard to the general astonishment and fear. Even the Indians, then around here, shared in the superstition that something terrible was about to happen, and this remarkable freak of the great river was a warning to desist from wickedness "

APPENDIX G

RESOLUTIONS OF THE BUFFALO GENERAL ELECTRIC COMPANY

In memory of its late president naming the great steam-power station The Charles R. Huntley Station.

Authorizing the erection of a memorial bronze tablet in the turbine room of the great plant.

RESOLUTIONS OF THE BUFFALO GENERAL ELECTRIC COMPANY IN MEMORY OF CHARLES R HUNTLEY

The Board of Directors of this Company is desirous of perpetuating the memory of Charles R. Huntley, late president of the Company and its directing head from the time of its organization. One of the outstanding achievements of Mr. Huntley's administration was the erection of the steam generating station located on the River Road in the Town of Tonawanda, now known as the River Station; therefore,

RESOLVED, that the River Station be designated for all time as the "Charles R. Huntley Station" as a perpetual memorial to Charles R. Huntley, in recognition and appreciation of his long and devoted service to this Company and of his vision and courage in planning and constructing this station during the early days of the World War to meet the immediate war-time needs of industry and to assure for the future the adequacy and continuity of the service of this Company.

RESOLVED, that a suitable tablet with appropriate memorial inscription be placed in the turbine room of the station and such other insignia be placed on the station as the Committee hereinafter appointed shall deem proper so as to perpetually dedicate the station to the memory of Charles R Huntley.

C. D. WARREN
Asst Secretary

December 10, 1926